



Alberta
OIL SANDS TECHNOLOGY
AND RESEARCH AUTHORITY

AOSTRA Field Pilot Projects



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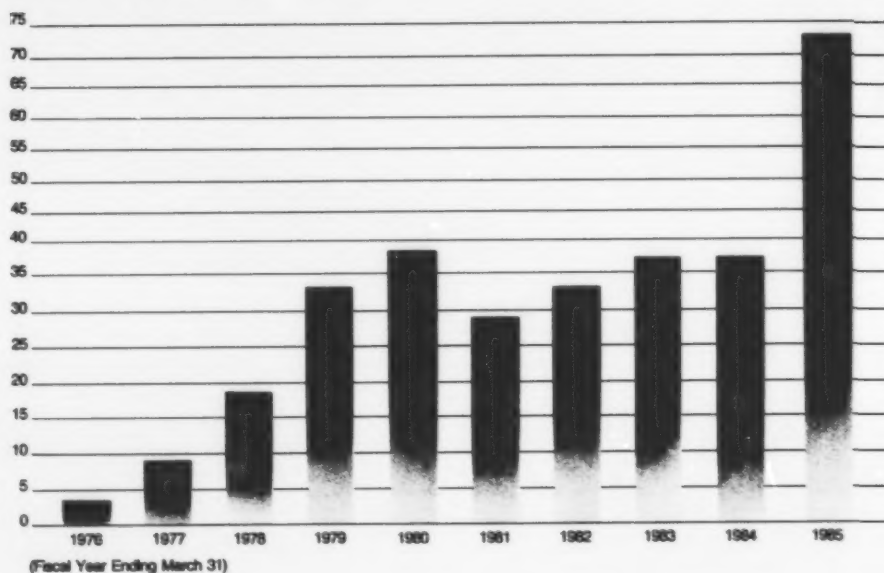
Annual Investment by AOSTRA in Oil Sands and Heavy Oil Technology
Commitments from AOSTRA Research Fund to March 31, 1985

AOSTRA is a provincial crown corporation established by an Act of Legislature in 1974, whose mandate it is to:

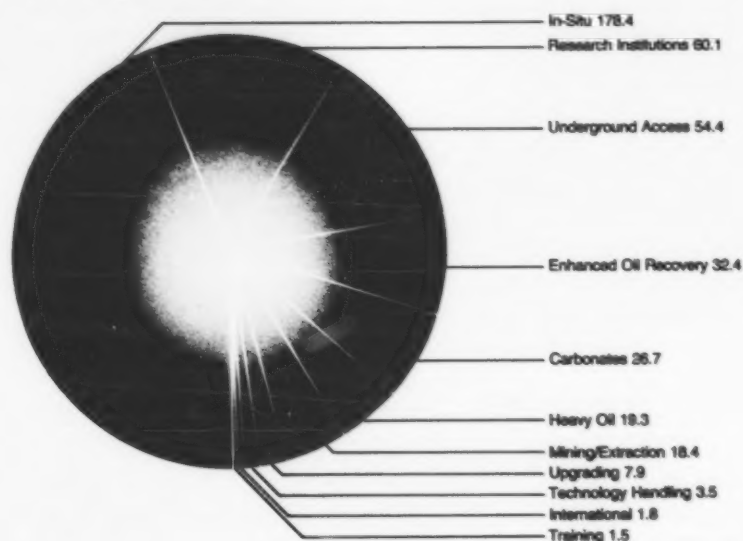
- 1) promote research and development into the technological methods required for the efficient and economic recovery and processing of crude bitumen and other oil sands products from the oil sands deposits, and the effective and economic recovery of crude oil through the use of enhanced recovery methods;
- 2) promote research into the technological methods required to ensure an acceptable quality of the environment during and after such recovery and processing operations; and
- 3) promote and implement solutions to technological problems impeding the development of production capacity to meet the demand of crude oil, synthetic crude oil, and products derived from crude oil.

The Authority's involvement in technology development ranges from fundamental, academic, and institutional research to the support of large-scale field pilots and demonstration units in cooperation with industry (foreign and national) and various government bodies, both federal and provincial.

Annual Investment by AOSTRA in Oil Sands and Heavy Oil Technology (1976-1985) (\$ Millions)



Commitments from AOSTRA Research Fund To March 31, 1985 (\$ Millions)





***From the Honourable John Zaozirny
Minister of Energy and
Natural Resources
Government of Alberta***

The Alberta Oil Sands Technology and Research Authority was established by the Government of Alberta in 1974 with a mandate to develop the technology to realize the potential of our province's vast heavy oil and oil sands deposits. Production of synthetic oil and bitumen from oil sands has grown to 13.5% of Canada's total oil production today and it will continue to increase in the years ahead. Although AOSTRA has been in existence for only ten years, it has made a significant contribution to this growth as have private sector companies which are also developing technology in these areas.

Several new commercial in situ projects have been recently announced or are in the construction stage. These projects are located in the Peace River and Cold Lake oil sands deposits and in Alberta's heavy oil deposits. AOSTRA and its industry partners have played a key role in developing the technology permitting some of these projects to proceed. This technology has the potential for application in adjoining areas of the same deposit or similar fields in other locations. AOSTRA has also made progress in developing technology for enhanced oil recovery from depleted conventional oil fields.

The Ten-Year Review of AOSTRA's performance undertaken by some 65 external expert reviewers concluded that "the overall performance of AOSTRA has been more than satisfactory and that the Authority should continue to pursue its mandate". This conclusion was reported along with recommendations for renewed or increased activities in some technology areas and suggestions for change of emphasis or new areas for research. These and many other recommendations have either been acted upon or are under consideration.

Much remains to be done. There are many technologies being developed which will require further work or field demonstration in the immediate future. This work by AOSTRA will undoubtedly contribute to the development of a highly technical and versatile oil sands and heavy oil industry which we hope will ultimately be sufficient to satisfy both our domestic oil requirements and export opportunities.





To the Honourable John Zaozirny Minister of Energy and Natural Resources

I have the honour to present this review and progress report covering the first ten years of operations of the Alberta Oil Sands Technology and Research Authority (AOSTRA). This report highlights the major accomplishments of the Authority and previews the planned activities for the next five years.

The completion of a ten-year technical review was timed so that it would coincide with the preparation of this report. This has been most opportune since it provided me with a comprehensive review of AOSTRA's past activities along with many excellent suggestions on which to base my first report since assuming the office of Chairman in September of 1984.

A summary of the technical review findings follows the Chairman's Report and the letter to the Authority from the Technical Review Steering Committee is shown on Pages 54 and 55. Many of the conclusions, suggestions, and proposed changes are highlighted in the major sections throughout this report.

I am pleased to report that progress to date, in the in situ area, has been most impressive. The early goals of AOSTRA included the development of a technical process for each of the major oil sands deposits in Alberta. To date, commercial facilities have been built in the Cold Lake deposit by BP Exploration Canada Limited; and in the Peace River deposit, Shell Canada Resources Limited is currently constructing commercial facilities. In the Athabasca deposit, Canterra Energy Limited and Tenneco Energy Limited have made excellent progress in the development of a successful process. Each of these in situ technologies has been developed by AOSTRA and their industrial partners. In the future we will focus our attention on the development of new technical processes for the much larger Carbonate deposit.

Advances have been just as successful in the development of enhanced oil recovery technology. Commercial projects have already been announced by two AOSTRA partners to employ AOSTRA/industry developed technology in order to increase recovery in conventional oil reservoirs. It is quite likely there will be opportunities to sell these technologies to other companies for use in similar oil fields.

Several projects are continuing in the mining and extraction areas attempting to solve the problems of low recovery from poorer grade ores, sludge formation, high cost overburden removal, and resource conservation. One of the most promising technologies owned by AOSTRA and being developed in conjunction with UMATAC Industrial Processes, a division of UMA Engineering Ltd., is a direct retorting process which has the potential to solve the low recovery problem and eliminate sludge formation. AOSTRA plans to demonstrate the Taciuk process in the near future with other participants. A second project, the Underground Test Facility located in the Athabasca deposit, is proceeding on schedule and within budget. Process testing will begin in the latter part of 1986 as reported on Page 23.

In upgrading AOSTRA has done considerable work in attempting to improve the yield of useful liquid products from bitumen, produced by both mining and in situ methods. Progress to date is highlighted later in the report but, as is indicated, much remains to be done. A greater part of our future effort will be directed to an improved upgrading process to increase the yield to a more acceptable level.

AOSTRA plans to continue technology development on many fronts as outlined throughout the report.

We plan to be more aggressive in the area of technology sales and dissemination. A new thrust is underway to assemble all AOSTRA technology and data into discrete and useful packages for future sales.

More emphasis will be placed on favorable economics by forecasting the economic advantage of projects employing newly developed technology.

It is recognized that basic institutional research is a necessary component of new technology development and our efforts will, therefore, continue at about the same level as in the past. However, research carried out by universities and research institutes will, in future, be redirected in order to become more relevant to field projects and more useful in the shorter time span.

AOSTRA is recognized as a world leader in the development of oil sands and heavy oil technology. International activities will continue to be pursued through UNITAR, the United Nations organization for oil sands and heavy oil activities, and through Memoranda of Understanding with foreign state-owned oil organizations.

I have been most pleased to see the AOSTRA staff mature and develop into an efficient and well-balanced team. This team, with the help of the broad information base which has been established over the past ten years, is capable of handling the anticipated future workload most effectively. Our continuing mandate will be to combine research activities with the resources of institutes, universities, industry, and government to generate new or improved technology for solving existing oil field problems and to develop more efficient production from Alberta's hydrocarbon resources.

Respectfully submitted,

R. D. Humphreys

R.D. Humphreys, P.Eng.
Chairman

The first comprehensive review of AOSTRA activities was presented in 1980, in our Fifth Annual Report and Five-Year Review. That review, carried out by AOSTRA staff, summarized our progress and displayed the position of AOSTRA's development of new or improved technology for oil sands and heavy oil applications.

This Ten-Year Review and Progress Report has been designed to update and elaborate on that first report. To produce a more useful and comprehensive picture of AOSTRA's activities we assembled a team of internal collators and outside expert reviewers. The internal staff prepared concise summaries of all AOSTRA projects to July 31, 1984. These were reviewed by the external experts in conjunction with comments made by the appropriate individuals from industry or institutes associated with the projects. The resulting conclusions, suggestions and recommendations are highlighted throughout this report.

The review was managed by a three-man Steering Committee, comprised of Mr. J.E. Konrad, Chairman, Mr. R.S. Aberg and Mr. M.A. Carrigy. Their overall conclusions are expressed in a letter to the Chairman of AOSTRA, which is reproduced on Pages 54 and 55 in this report.

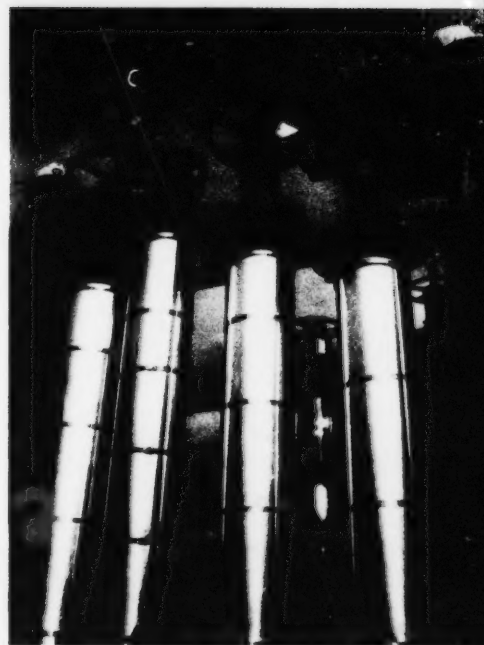
The most significant and precise conclusion reached in the review is contained in the closing paragraph of the Steering Committee's letter:

"The Steering Committee has concluded that the overall performance of AOSTRA has been more than satisfactory and that the Authority should continue to pursue its mandate. Some changes in emphasis have been recommended which deserve serious consideration by the Members."

The major changes in emphasis recommended by the review team are discussed later in the relevant sections of this report. In all, the review team made some 140 individual recommendations, many of which were minor in nature and have already been acted on by the Authority Members. The major recommendations, such as expanding the scope of activities in a program or beginning new activities, are being considered by the Members. The outcome will depend on other projects under consideration. One example where the Members can take immediate action is on the recommendation by several reviewers to improve internal AOSTRA communications. All other recommendations are under review and will be implemented as they are adopted by the Members.

Our policy is to work with industry partners on major projects and, in some cases, this has led to less than ideal project execution and control. The reviewers have made comments and recommendations which will be reflected in future AOSTRA agreements. Some shortcomings in these areas have stemmed from unforeseen circumstances such as changes of company ownership, management, or policy and from inadequate provision in original contracts to cope with such events. Future agreements with partners will include additional clauses to prevent such problems from arising.

Although the technical review was not intended to be a financial audit, the reviewers did look at the value received from expenditures and the potential commercial viability of the technology being developed. In general, they concluded that AOSTRA has received good value for monies expended and that there is good potential for commercial marketing of the technology



from several of the major projects completed. The reviewers also concluded that of the remaining projects reviewed, half require further development, while some are of questionable economic value and should be discontinued.

The comprehensive and independent technical review was carried out over a 16-month period at a cost of less than 0.2% of AOSTRA expenditures to date. This was a most worthwhile expenditure because the review provided AOSTRA with many valuable comments and recommendations on our program. The 65 technical experts from around the world also gave us suggestions on how to improve our future performance. The outcome of this exercise will be an immensely improved technology development program for AOSTRA during our next phase of operations.

AOSTRA was established in 1974 to promote the development of new oil sands technology. Two specific goals set by the Authority Members at that time were:

- a) to increase the pace of research and make it continuous, where previously it had been intermittent or short term in nature, and
- b) to ensure the use in Alberta of the most advanced technology available.

In carrying out its mandate, AOSTRA has adopted the following principles as a guide to program selection:

- To judge all proposals for research and development programs on a fair and equitable basis.
- To respect and protect proprietary rights of technology owned by applicants and also technology developed with public funds.
- To make available the technology derived with AOSTRA funding to all interested parties on fair business terms.
- To evaluate all promising research concepts regardless of geographical source. (Where appropriate, non-Canadian equipment and expertise may be used during the early part of a research and development program. However, as soon as a continuing program has been defined, every reasonable attempt will be made to locate the research activities in Alberta.)
- To "contract out" research programs to the private sector, and to utilize existing research organizations to the fullest extent possible.
- To cooperate with research agencies of other governments who have common interests and goals.
- To encourage individual inventors and private research laboratories to participate in oil sands and heavy oil research activities.

Guidelines describing how these principles are applied in AOSTRA-funded projects are provided on Pages 63 and 64 of this report.

Authority Members

The Government of Alberta has appointed, as Members of the Authority, Alberta citizens knowledgeable about the oil sands and heavy oil industry and experienced in the development and management of technical endeavors. The Members have the responsibility for the selection of projects to be funded, and for ensuring that the technology developed is efficiently and effectively used in Alberta.



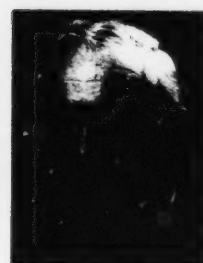
Reginald D. Humphreys
Professional Engineer
Chairman 1984 - present
Member 1976 - 1979



Maurice A. Carrigy
Professional Geologist
Vice-Chairman
1975 - present



Harry E. Gunning
Chemist
Member
1979 - present



James A. Harvie
Professional Engineer
Member
1979 - present



Fred A. Kidd
Professional Engineer
Member
1975 - present



J.E. (Bud) Miller
MLA Lloydminster
Member
1982 - present



Ernest J. Wiggins
Professional Engineer
Member
1977 - present

Current Members

Eight other Members have also served on the Authority Board, and have played a key role in developing the AOSTRA program.



Edward E. Ballantyne
Veterinary Scientist
1975 - 1978



Clem W. Bowman
Professional Engineer
Chairman
1975 - 1984



Paul E. Gishler
Chemist
1975 - 1979



E. Peter Johnson
Professional Engineer
and Patent Agent
1975 - 1976



Milt G. Pahl
MLA
Edmonton Millwoods
1981 - 1982



Ken Paproski
MLA
Edmonton Kingsway
1980 - 1981

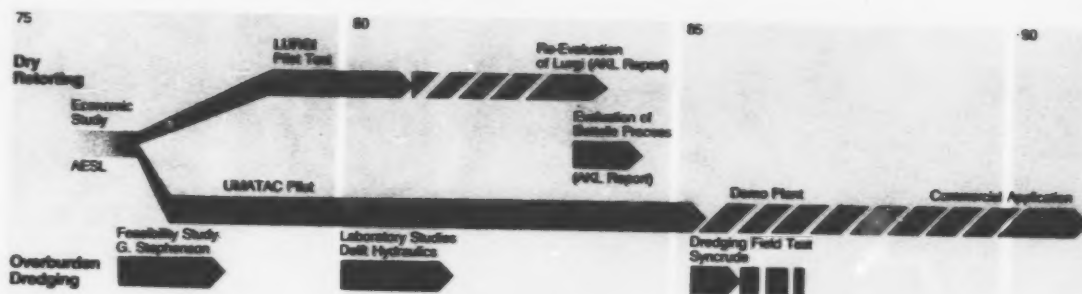


Frank K. Spragins
Professional Engineer
1977 - 1978



Norm A. Weiss
MLA
Lac La Biche/McMurray
1979 - 1980

Former Members



Possible development profile for AOSTRA's surface mining/bitumen extraction program

The largest single hydrocarbon accumulation in Alberta - and perhaps in the world - the Athabasca deposit is the only oil sands deposit in the province with some reserves shallow enough to be mined and others deep enough to require in situ recovery processes.

This deposit contains about 114×10^9 cubic meters of bitumen, 10% of which is close enough to the surface to allow the application of open-pit mining and bitumen extraction from whole oil sand in a processing plant. The two plants already in commercial production are capable of producing 30,000 cubic meters of synthetic crude oil per day using bucket wheels and draglines for mining, the Clark Hot Water Extraction Process for bitumen separation, and delayed coking or fluidized bed coking for primary upgrading.

Some of the deficiencies in the current mining, extraction and upgrading technologies are: the low depth limitation on the economic overburden removal, poor bitumen recovery from lower grade ores, the need for very large tailings disposal ponds, relatively low liquid yield from the upgrading of bitumen, and the high emissions of sulfur dioxide to the atmosphere. AOSTRA has funded many research projects designed to alleviate these deficiencies. (Several of

the more promising projects in AOSTRA's mining-extraction-upgrading program are described later in this report.) These include low-cost removal of overburden by dredging, a retorting system to increase recovery from low-grade oil sands, production of dry tailings sand, and the addition of hydrogen directly to the bitumen to increase the liquid yield and to reduce the emissions of sulfur dioxide to the atmosphere.

For the deeper portion of the Athabasca deposit, AOSTRA and its industrial partners are conducting field experiments to find an economically acceptable in situ recovery process. In situ combustion experiments were tried at the Gregoire Lake Pilot from 1977 to 1981 without success. New experiments involving steam and additives are now being tried or considered using vertical wells at other sites.

A bold departure from the normal in situ testing is under construction at a site 45 km northwest of Fort McMurray, where AOSTRA is building an underground facility for the testing of horizontal drainage wells. Short descriptions of some of the projects in AOSTRA's Athabasca program are highlighted in this section.

The Problem of the Low-Grade Oil Sands

The diagram to the right graphically illustrates the sharp drop-off in the recovery of bitumen from oil sands by means of the hot water process. Bitumen currently lost to the tailings could be recovered by:

- i) improvements to the hot water process
- ii) concentration and treatment of sludge from the tailings ponds, or
- iii) a non-aqueous process which is less sensitive to ore grade.

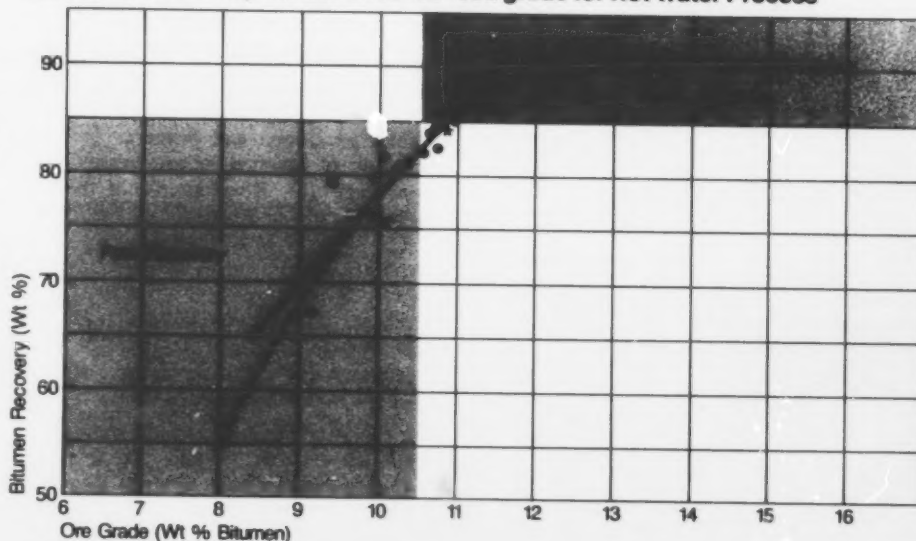
The first option of improving the hot-water method is being actively pursued by the operators of two commercial processing plants. The second option, research on the recovery of bitumen from the tailings, is being funded by AOSTRA and Suncor using the *Oleophilic Sieve Process*. The third option can be satisfied by either a dry retorting process such as the *Taciuk Process* or a solvent extraction process, both of which are under investigation by AOSTRA.

The Oleophilic Sieve Process

The Oleophilic Sieve Process was conceived by Alberta inventor Jan Kruyer at the Alberta Research Council and subsequently developed by the Oleophilic Sieve Development of Canada Ltd. (OSDCL). The current configuration being tested by AOSTRA, in cooperation with Suncor, is designed specifically to recover the bitumen contained in the tailings pond sludge. This configuration uses an oleophilic belt and rotating drum to collect the bitumen and squeeze it out into a collector (see Figure). Early results have been encouraging, and the process could find a use as an addition to existing commercial plants. Patents to this process are currently held by OSDCL of Edmonton, and AOSTRA has obtained licensing rights for effluent stream applications of the oleophilic sieve technology. Our technical review team considered this to be a well defined and successful project which may lead to commercialization.

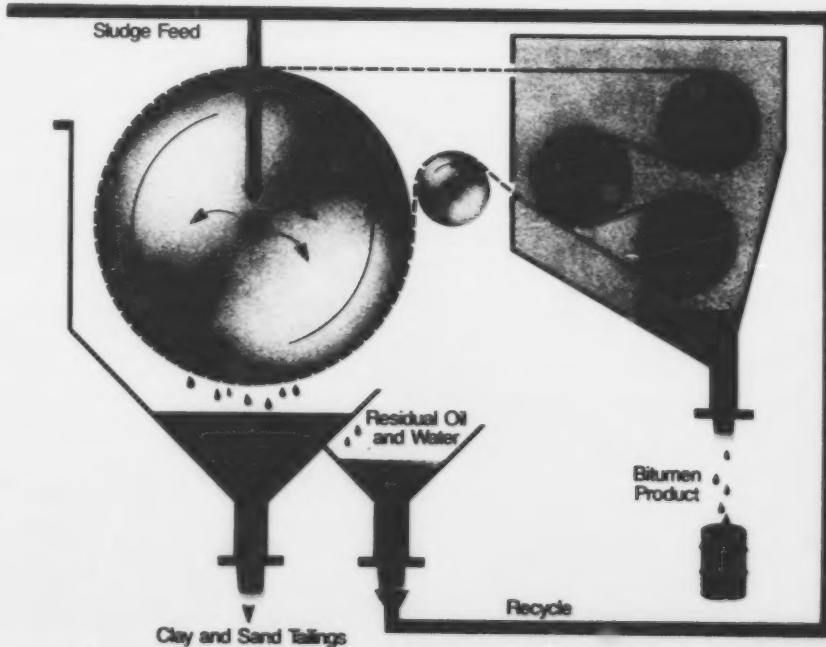
Simplified illustration of the Oleophilic Sieve Processor or Kruyer Process

Extraction efficiency versus oil sands feed grade for Hot Water Process



Relationship between grade of oil sands and bitumen recovery in the Clark Hot Water Process

Oleophilic Sieve Process



Retorting Whole Oil Sand: the Taciuk Processor



Five tonnes/hour Taciuk Processor in Calgary

The Taciuk Processor, an invention by William Taciuk, an Albertan, is based on direct retorting of oil sand to combine extraction and primary upgrading of bitumen in one vessel (see figure Page 15). Development of the processor has been carried out for AOSTRA by UMATAC Industrial Processes, a Division of UMA Engineering Ltd., with full funding by AOSTRA. Patents and licensing rights to the Processor are held by AOSTRA and certain engineering and manufacturing rights are held by UMATAC.

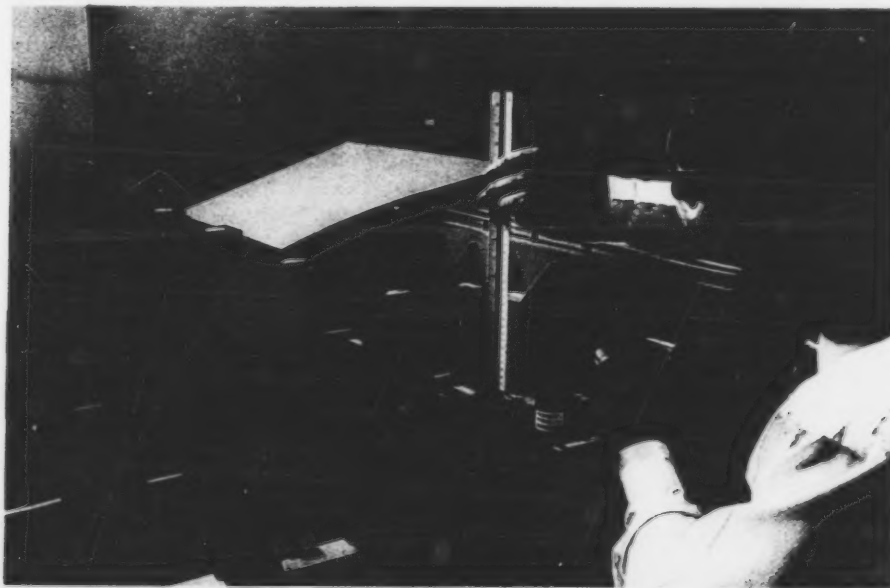
The Taciuk Processor consists of a horizontal, rotating cylinder containing separate zones for each process step. Run-of-mine oil sand is fed into a preheat zone where heat recovered from hot sand tailings raises the temperatures of the oil sand. The preheated oil sand is transferred into a reaction zone where it is mixed with hot sand recycled from a combustion zone. In the reaction zone, the temperature of the oil sand is raised high enough to crack the heavy bitumen into lighter products. The cracked products vaporize and are removed from the Processor for subsequent processing. Coke is produced when bitumen is

cracked and is deposited on the sand. The coked sand is transferred to a combustion zone, where the coke is burned with a controlled amount of air to provide heat for the processor. Supplemental fuel can be added to the combustion zone as required to maintain and control the cracking reaction.

A portion of the hot sand from the combustion zone is recycled to the reaction zone and the remaining hot sand is transferred to a heat exchange zone. The sand is cooled by transferring heat from the sand to the oil sand feed in the preheat zone.

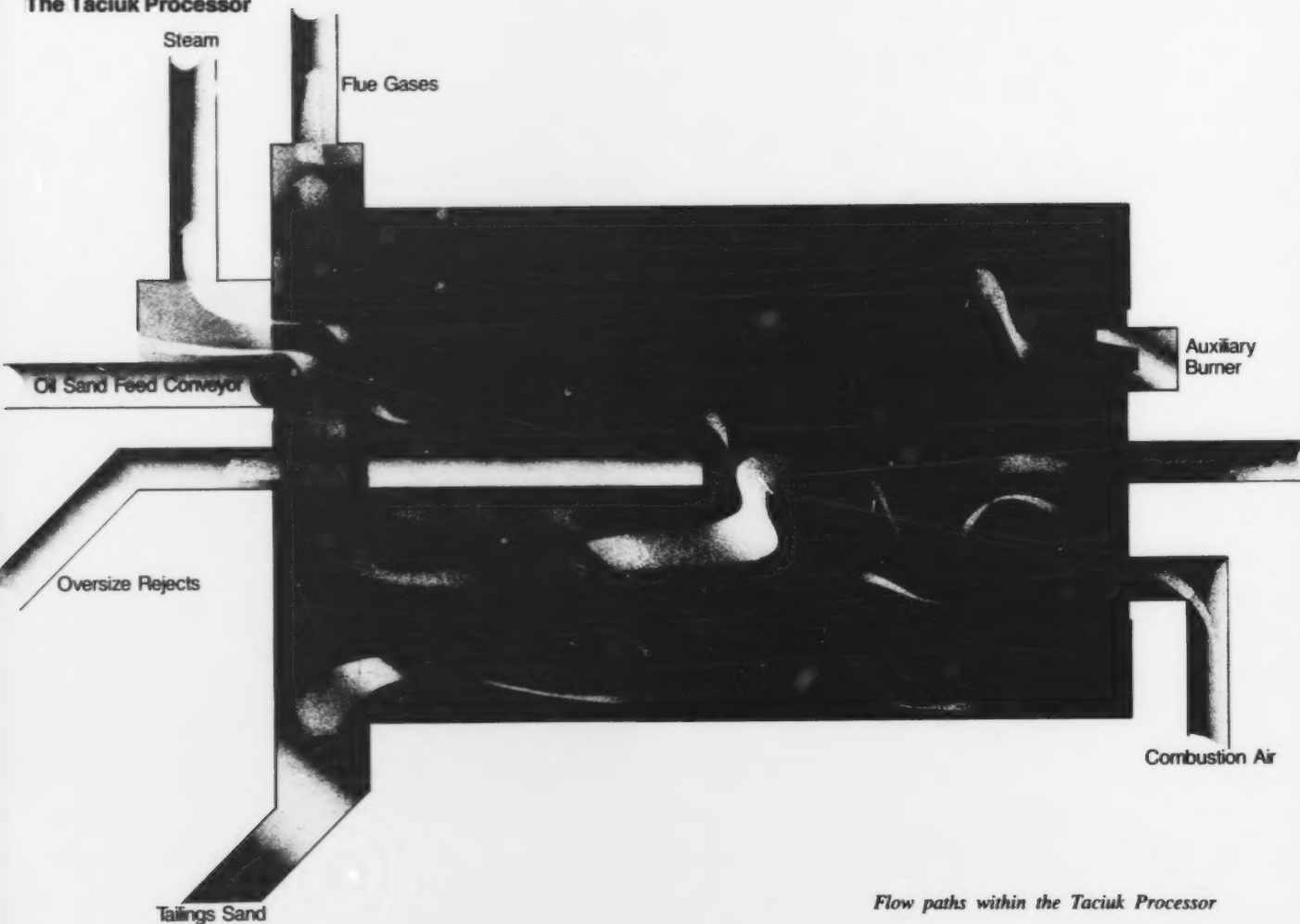
Extensive pilot testing of the Processor has indicated that it is relatively insensitive to oil sand quality. The Processor maintains a high hydrocarbon recovery for all grades of oil sand feed, and produces a clean dry sand tailings for disposal.

This project was considered satisfactory by the technical review team, with good to excellent value received for monies spent. It is considered to be the best of emerging extraction technologies by some of those oil companies that reviewed the pilot test results; some of these companies are now considering taking an active role in its further development.



Scale model of Taciuk Processor used to assist in the design of a commercial plant

The Taciuk Processor



Flow paths within the Taciuk Processor

Lower Cost Removal of Overburden From Oil Sands

Cost analyses of surface mining operations have indicated that significant savings could be achieved if the cost of overburden removal could be lowered. AOSTRA believes one of the most effective methods for removing the overburden from oil sands is by hydraulic dredging. Although several attempts have been made to develop a conceptual dredging plan, the stability of the stacked materials and the need for double handling remain as obvious drawbacks. It would be advantageous from a number of viewpoints if the tailings from the extraction plant and the

overburden could be mixed and transported to the disposal area in one operation.

AOSTRA has completed feasibility studies of the concept which indicate that the funding of a pilot test program is warranted. This program would determine the stability of the materials and field test hydraulic dredges of the size and power needed to demonstrate the benefits of this system. Two of the three studies conducted by AOSTRA were rated as successful by the technical review team, while a small scale laboratory test was rated only partially successful due to equipment and sampling deficiencies.

Dredging test of overburden at Syncrude's Mildred Lake location



A Center for the Demonstration of New Extraction Processes

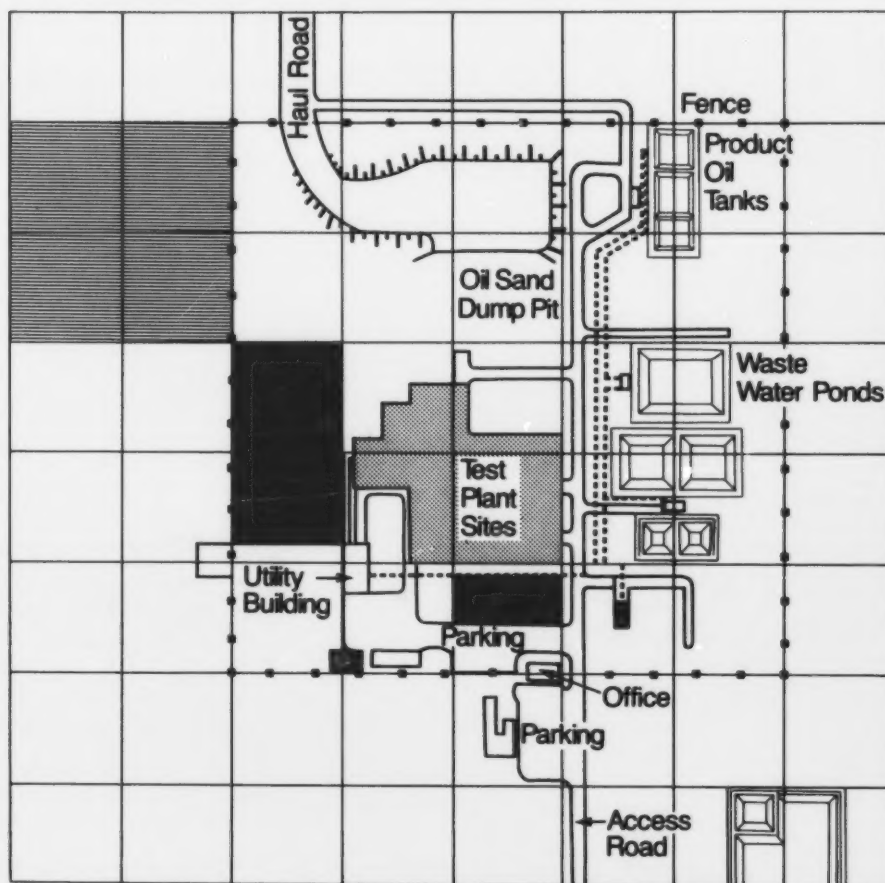
A new process generally will not displace one that is commercially proven until its reliability has been demonstrated by prolonged operation in industrial scale equipment. This is an expensive procedure, usually beyond the financial capability of most developers of technology.

To spread the financial risk of new technology development, AOSTRA has asked the owners of oil sands mining leases to join us in providing the infrastructure (utilities, oil sands feed, disposal facilities, etc.), to allow process developers to demonstrate promising new oil sands extraction processes at relatively low cost. To this end, AOSTRA, in cooperation with industry and the Federal Department of Energy, Mines, and Resources, has designed and costed an Oil Sands Demonstration Center near Fort McMurray.

Management principles and terms for use of the facility by technology developers have been formulated. The construction of such a facility will not proceed, however, until a number of processes are funded for demonstration. In the meantime, a testing site has been set aside and awaits the agreement of interested parties to fund the commercial demonstration of new processes.

The technical review team concluded that while this facility was required at the time it was initiated, its validity today is questionable. Since the project had progressed only to the conceptual stage, and as AOSTRA had already decided to hold further development in abeyance, this opinion coincided with our own.

OSDC Site Layout





Inducing massive fractures in the Athabasca deposit requires the mobilization of specialized skills and equipment



Fracturing

It has long been argued that steam and combustion processes would be far more effective if early communication could be established between wells by lifting the strata above the base of the oil sands. Numerous attempts have been made to achieve this objective, but no consistent positive results had been obtained prior to 1976.

In 1976, AOSTRA joined with Numac Oil & Gas Ltd., at a site south of Fort McMurray, to field test the best technology then available. With the technical assistance of Amoco Canada Petroleum Company Limited, the fractures created in this test were filled with cement. Movements were monitored on the ground surface by tiltmeters and accurate leveling. Holes were also drilled to find the cement-filled fractures themselves. Unfortunately, horizontal communication paths were not established at this depth, and a method for consistently achieving horizontal fractures at depths greater than 300 meters still remains to be found. (The theory of fracturing being pursued by AOSTRA in the laboratory is described in a later section of this report.)

The technical review team considered this to be a well defined project with excellent field performance which resulted in only partial success. The value of the results was deemed inconclusive, and further development will be required.

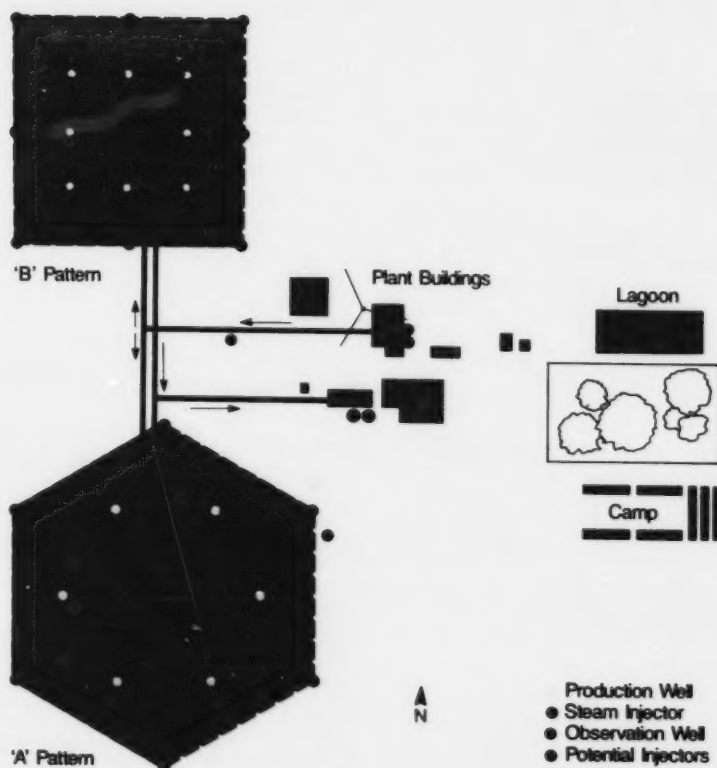
Location Map





Steam Drive

In 1983, AOSTRA joined an established in situ pilot being operated by Canterra Energy Limited on behalf of themselves and Tenneco Energy Ltd., which is located in the Athabasca deposit 77 km north of Fort McMurray. The ambitious pilot is designed to test a modified steam drive in two patterns drilled in seven- and nine-spot configurations. Testing is now in its fourth year at this site and will be continued as long as encouraging results are obtained. Results from this project were rated as inconclusive by our outside evaluators, but more recent results show much improvement and the potential for commercial development.



*Plot plan for the
AOSTRA/Canterra/
Tenneco steam drive
pilot in the
Athabasca deposit*

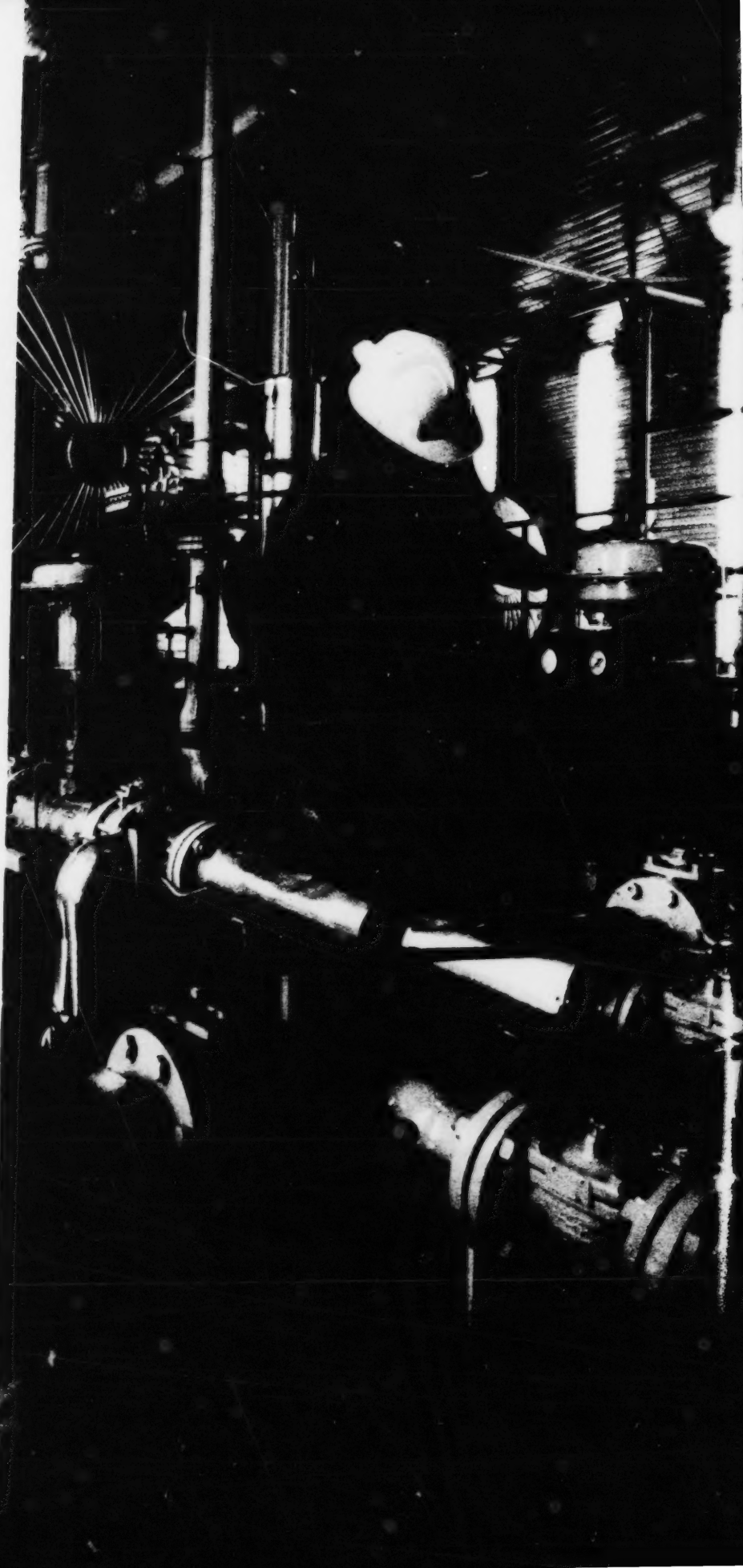
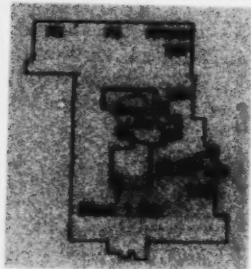
Steam With Additives

GLISP

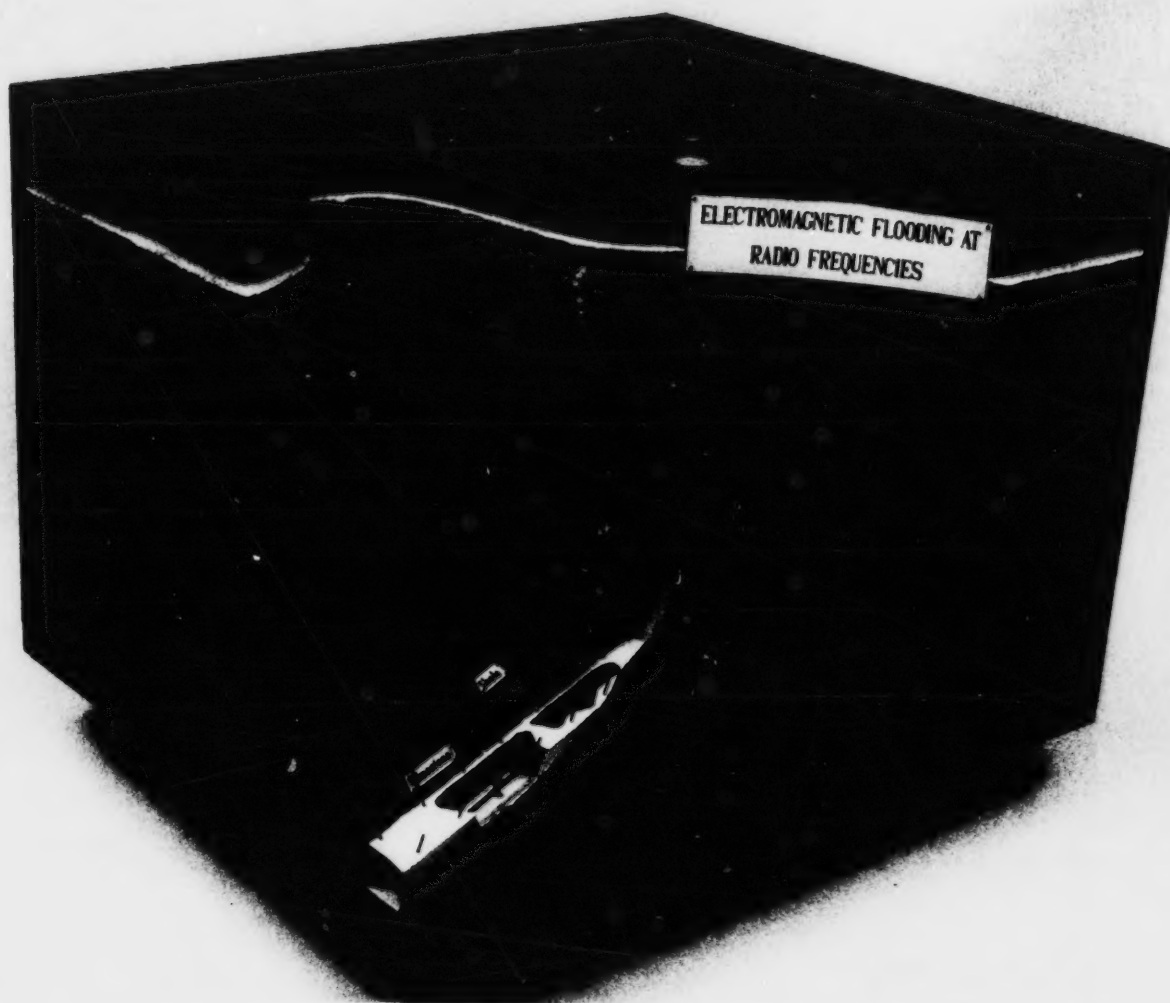
Following the failure to achieve basal interwell communication in the Gregoire Lake combustion test at Block 1, Amoco Canada Petroleum Company Ltd. and AOSTRA met to design a new series of experiments. These promised high recovery from an in situ steaming process in the Athabasca deposit. This collaboration has resulted in a series of tests being planned for a new site on Amoco land, which involves the testing of steam and the use of additives to increase recovery. The additives to be tested have previously been shown effective in laboratory tests at the Alberta Research Council and now need to be proven in the field.

This project was in preliminary stages at the time of our ten-year review and reviewers' comments could not be made on the completed project. However, progress to date was judged to be satisfactory.

Pilot Sites



A physical model located at the University of Alberta is used to determine parameters that describe how a reservoir might behave when subjected to an applied electrical current.



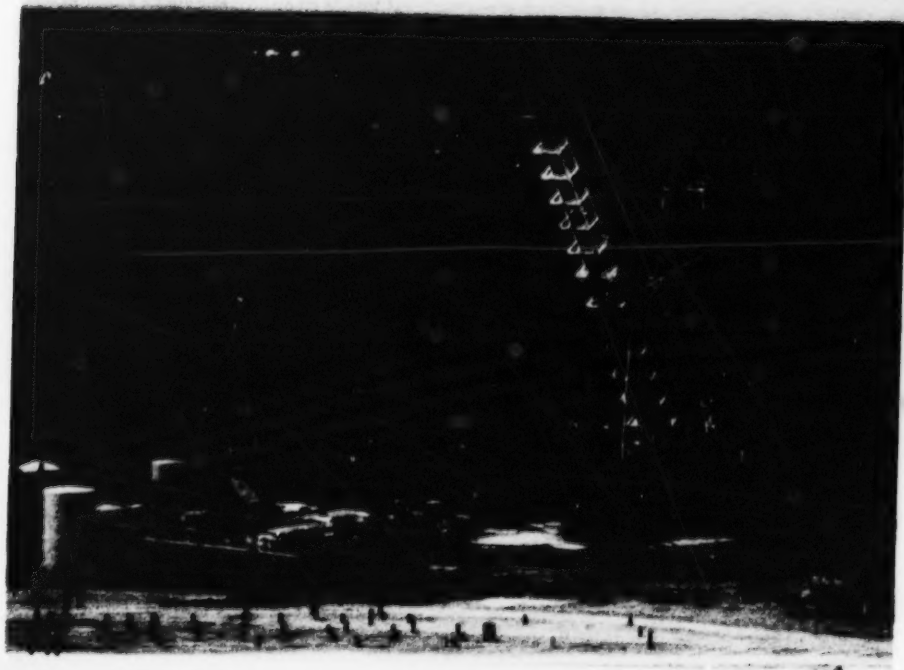
Electrical Heating

High viscosity of the bitumen in the Athabasca deposit and the impermeable nature of the rich oil sands found there have made it difficult to use viscosity-reducing fluids directly on large volumes of the reservoir without disturbing the matrix by fracturing. An attractive alternative would be to heat the reservoir in situ electromagnetically by resistance, low frequency radio waves, or by induction. Each of these concepts has been studied extensively, utilizing electrode configuration models. Measurement of the conductive properties of the strata was carried out

at the University of Alberta with AOSTRA funding. Elsewhere, independent field pilot work on resistance heating has been conducted by Petro-Canada Inc., Canadian Occidental Petroleum Ltd., Esso Resources Canada Ltd., and Japan Canada Oil Sands Limited (PCEJ Group) in the Athabasca deposit and later acquired by AOSTRA. The electrical properties of oil sands and contiguous strata are not yet sufficiently well known to justify our further participation in a field pilot. Additional small scale studies are needed in this area before a full scale field pilot test is warranted.

Horizontal Wells - Slant Hole Drilling

Numerical modeling of reservoir performance in Alberta has suggested that where the geology is favorable, horizontal wells may provide better drainage than vertical wells. The technology of drilling horizontal wells from the surface is already available if the depth is great enough to allow deviation. Where shallow horizontal wells are required, it is necessary to drill the wells with a slant rig. Slant drilling and deviated well technology are rapidly being developed by industry in Alberta in response to the need for cluster drilling in shallow oil sands deposits to reduce the amount of surface disturbance.

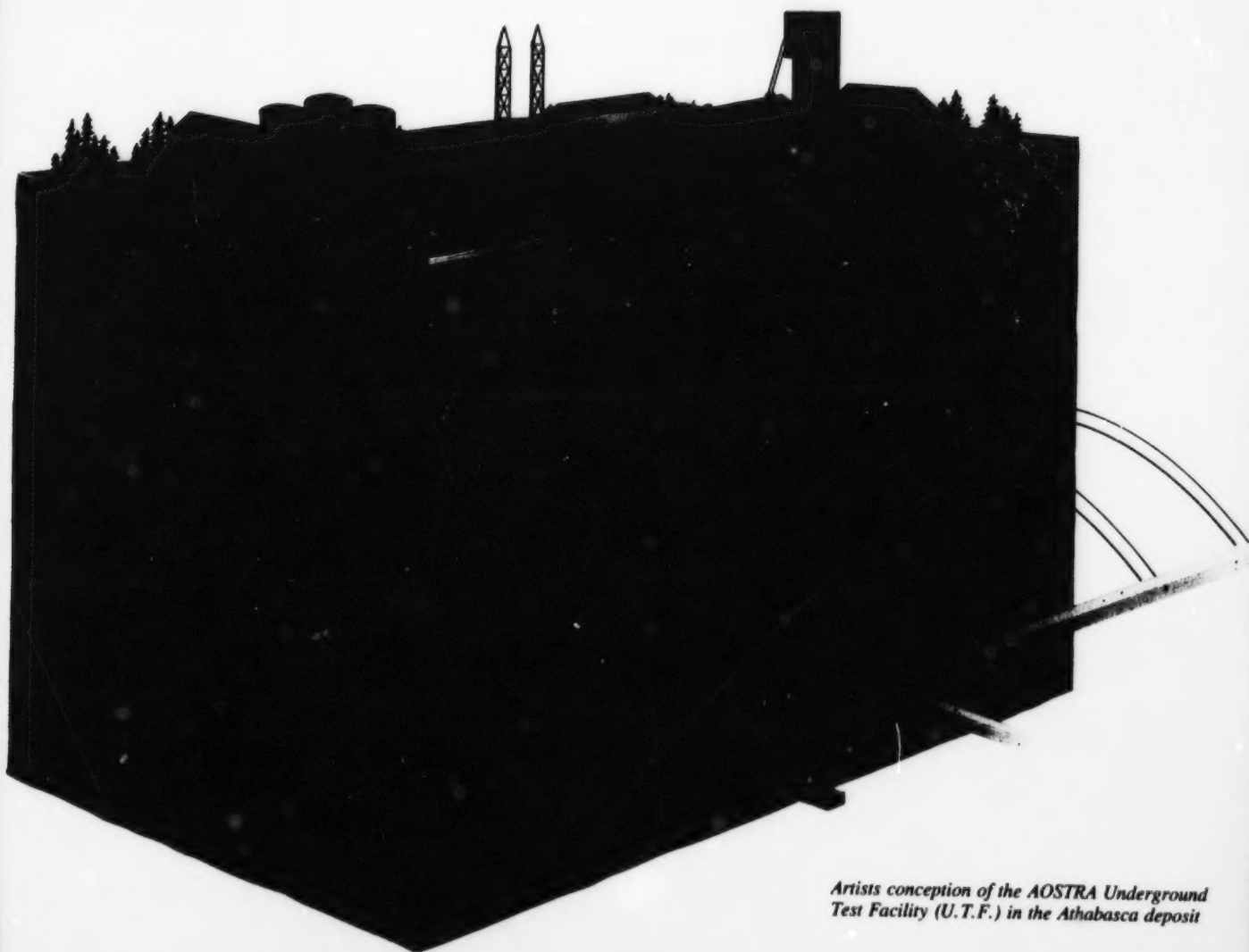


(Photos provided by North Eastern Group)

Horizontal Wells - The Underground Test Facility

After nine years of study and testing by AOSTRA and others, the economic feasibility of emplacing horizontal wells at the base of the oil sands reservoir will finally be "put to the test" when an Underground Test Facility (UTF) is completed at a site 45 km northwest of Fort McMurray. Now under construction, the facility is designed to test thermal processes by using horizontal wells to heat and drain the reservoir. The testing program will include the design, construction, and

operation of new horizontal well drilling equipment, completion hardware, and production systems. These have been designed to achieve maximum recovery of bitumen from the reservoir using gravity drainage mechanisms in an underground environment. The technical reviewers considered this project as well defined with good to excellent results to date. The project review was based on progress to date, and predicted good to excellent commercial potential for the overall project.



Artists conception of the AOSTRA Underground Test Facility (U.T.F.) in the Athabasca deposit

Wabasca Deposit

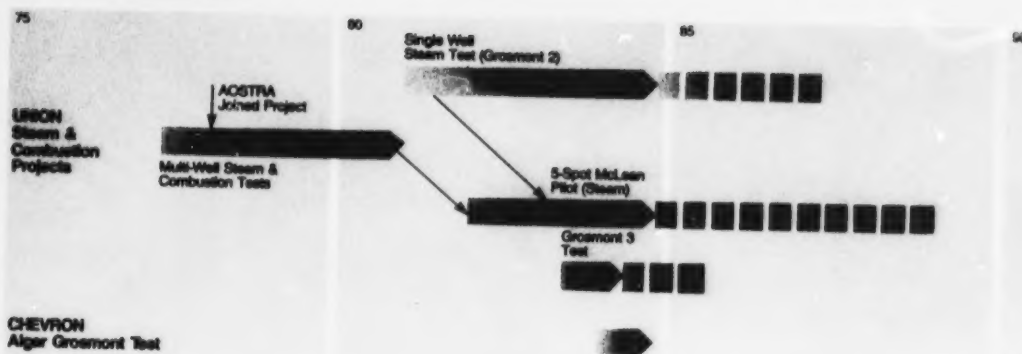
The Wabasca deposit has recently been absorbed as a separate entity into the Athabasca deposit, which now includes the lower Clearwater and Grand Rapids A and B reservoirs. The main operator in the old Wabasca deposit was Gulf Canada Resources Inc., which conducted six experimental pilots. While AOSTRA does not have any pilots in the Wabasca deposit, we have purchased data from the General American Oils Ltd. pilot located in the Joli Fou area. This pilot was designed to investigate the effect of wet combustion and steam stimulation in the lower Clearwater formation. As the combustion test was not successful and the steam stimulation tests did not give encouraging results, the site was abandoned on February 4, 1983.

For this project, the review team concluded that the objectives and chances of success were reasonably good as originally envisioned for the reservoir. They were, however, very poor for the reservoir as actually encountered in the field. It was suggested that AOSTRA may have decided to purchase this data based on insufficient information. AOSTRA will, in future, endeavor to make certain that sufficient data are available before decisions to purchase are made.



An optimistic view for the future of in situ development of the Carbonate Trend

Bituminous Carbonates



Following the publication in 1978 of estimates of vast reservoirs of bitumen in the Devonian carbonates (underlying the Cretaceous oil sands in northern Alberta), a site to test in situ recovery techniques in the Grosmont formation was selected by Union Oil Company of Canada Limited.

The purpose of the pilots was to learn more about the carbonate reservoirs and to test their reaction to steam and combustion. The first tests were started in 1979, when high rates of recovery

were obtained in a single well steam stimulation test. Unfortunately, these were not confirmed in a subsequent multiwell pilot, jointly funded by AOSTRA, Union, and Canadian Superior Oil Limited. The current efforts of the partners in this joint venture are to learn more about the reservoir and, in particular, what process strategy is needed to tap its vast amounts of bitumen.

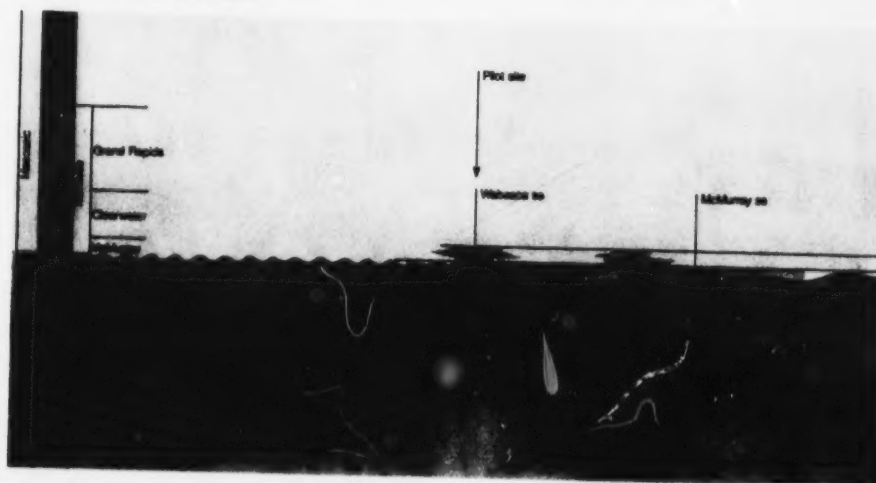
As too little is known about the carbonate reservoir, the review team considered this project to be only a

partial success. They recommended a more complete assessment of the reservoir conditions before embarking on more extensive field projects.

At another location in the carbonates, a single well steam test has been conducted by AOSTRA, Chevron Canada Resources Limited, and Canadian Occidental Petroleum Ltd. in an effort to learn more about the variability of carbonate reservoirs and to determine the effect of free gas on the production of bitumen.

Grosmont subcrop and overlying Mesozoic oil sands

Zone of Bitumen Impregnation



A multiwell pilot is being operated by Union Oil Company of Canada Limited on behalf of AOSTRA and Canadian Superior Oil Limited in the Carbonate Triangle, 100 km west of Fort McMurray.

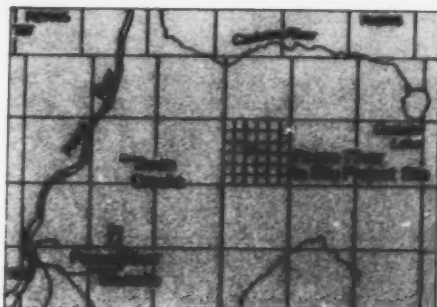
Geological factors play a significant role in the location and recovery of bitumen in the Grosmont formation, although a complete

understanding of the confinement mechanism will be needed before the bitumen in the reservoir can be produced successfully.

Peace River Deposit



Location Map



With ten billion cubic meters of bitumen in place, the Peace River deposit is the third largest of Alberta's oil sands deposits. As the deposit is found at 400 to 500 meters below the surface of the earth, it is too deep for open pit mining. However, a favorable feature of this deposit is a high water saturated zone in the bottom few meters of the reservoir. This zone of high water saturation ($> 50\%$) enables hot water or steam to be injected into the reservoir - well below the fracture pressure.

Together with Shell Canada Resources Limited (the operator), Shell Explorer Limited, and Amoco Canada Petroleum Company Limited, AOSTRA has been testing the concept of injecting steam into the bottom water sands and producing bitumen from surrounding wells. To alternately heat and drain the bitumen from the overlying sands, the pressure of the steam in the lower sands

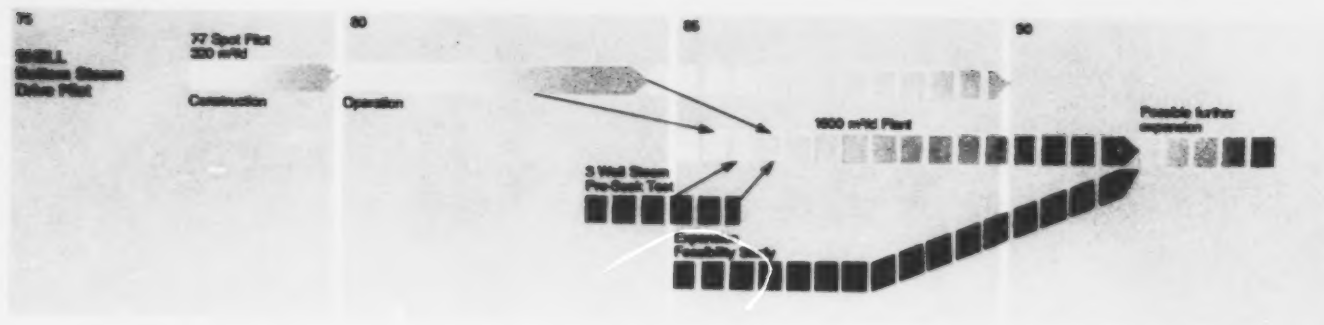
is raised and lowered in a cyclic manner.

Results have been so successful that Shell is presently expanding the pilot to a semicommercial oil sands operation. The first commercial production from this major oil sands deposit will produce 1600 cubic meters per day of bitumen. In 1985, 212 wells were drilled and the steam generating and production handling facilities were expanded.

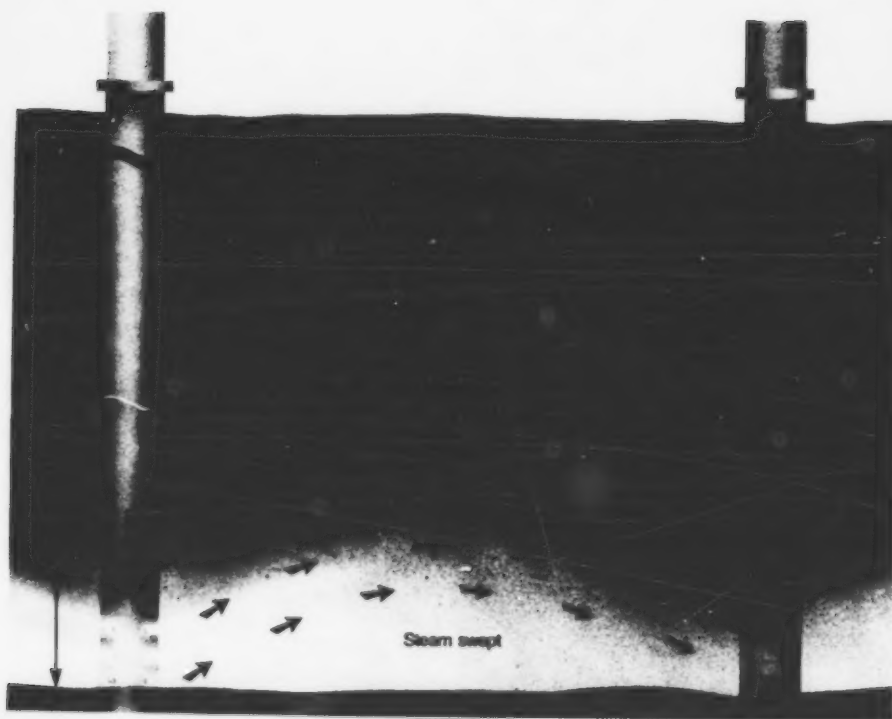
If the results of this initial expansion are encouraging, further additions are anticipated. These could lead to full commercial exploitation of this large resource. A possible schedule for this development plan is shown on the next page.

The project evaluation by our outside reviewers was favorable, and was confirmed by the fact that the project operator is proceeding to commercialization.

Peace River Deposit



Possible development profile for commercial insitu development of the Peace River deposit.

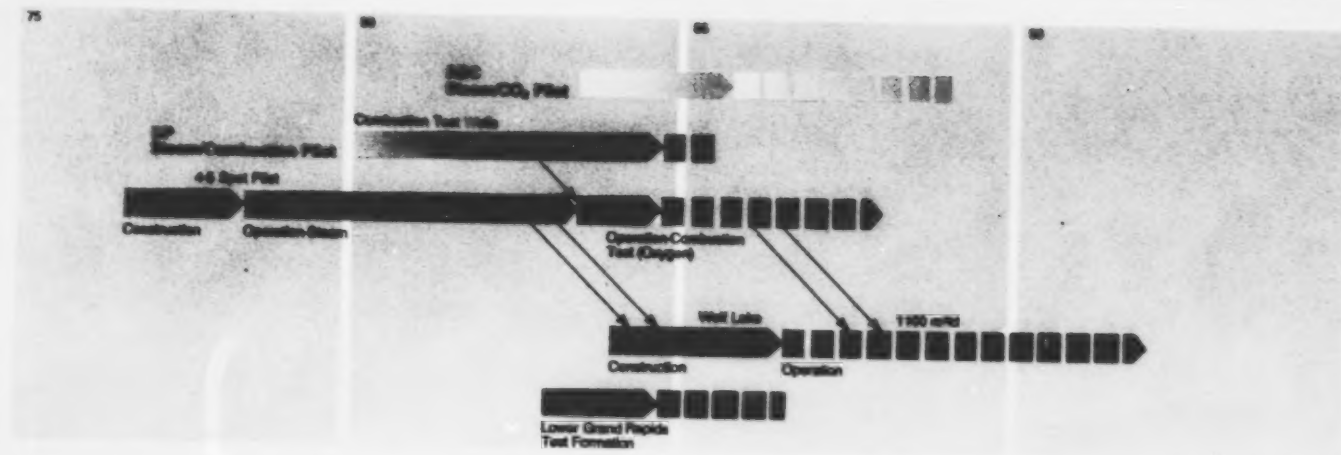


Conceptual drawing of the AO/STRA/Shell In Situ Steam Process

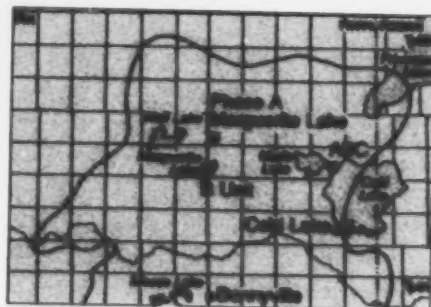


Possible development schedules for the AOSTRA-funded projects in the Cold Lake deposit

Cold Lake Deposit



Pilot Sites



The Cold Lake deposit is made up of four reservoirs of Lower Cretaceous age containing an estimated 25×10^9 cubic meters of bitumen. The lowest reservoir is in the McMurray formation, which is also the largest reservoir in the Athabasca deposit. Most of the experimental pilot activity in the Cold Lake deposit has centered on the Clearwater formation and has resulted in the current commercial production by Esso Resources Canada Ltd. and BP Exploration Canada Limited. Promising results have been obtained from production tests in the overlying Grand Rapids reservoir at one location. It is expected that, in the future, commercial production from the richer portions of all the Cold Lake reservoirs will be achieved.

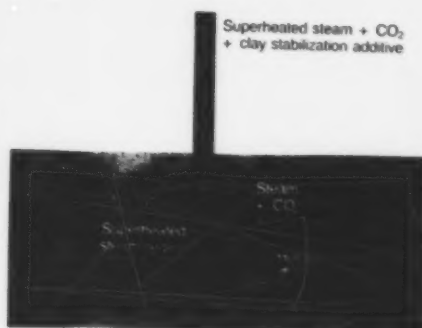
AOSTRA's involvement has been concentrated in the Marguerite Lake pilot with BP and its partners. The successful use of steam stimulation in the first phase of this pilot has encouraged BP and Petro-Canada Inc. to proceed with the Wolf Lake commercial 1100 cubic meters per day operation. In the meantime, the partners are pursuing use of oxygen in a follow-up combustion phase to increase the recovery from the preheated portion of the reservoir at the Marguerite Lake experimental site.

The reviewers judged this project to be a success, a conclusion which is borne out by BP's decision to proceed with a small commercial facility.

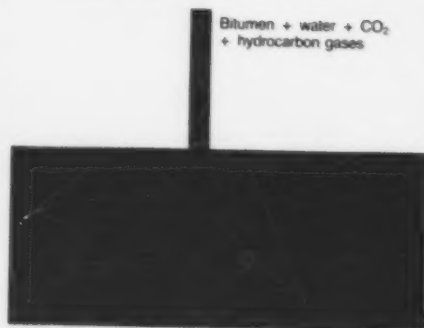
Fracturing tests and steam stimulation tests are also being conducted by AOSTRA, BP, and Petro-Canada in the Grand Rapids reservoir.

Laboratory research on methods for increasing production for steam projects has centered on the use of additives to the injection fluids. The AOSTRA, Bow Valley Resource Industries Ltd., and Cold Lake Heavy Oil Limited (ABC) pilot near Cold Lake (north of Grand Centre), is testing a treatment designed to mitigate the swelling effects of sensitive clays in lower grade parts of the Clearwater formation.

Injection Phase



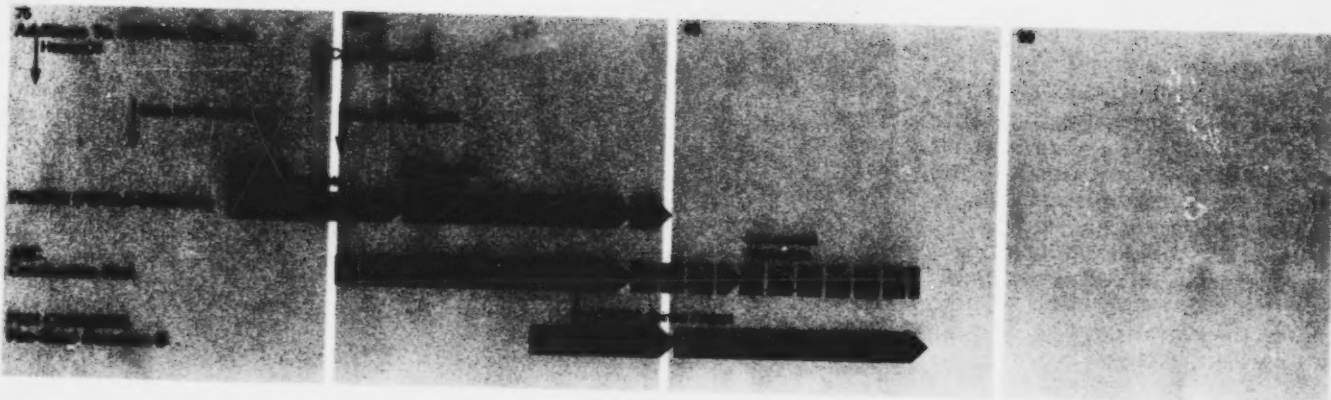
Production Phase



Injection and production steps in the Steam Stimulation Process

Possible scenario for the commercialization of AOSTRA thermal pilots

Enhanced Recovery - Thermal



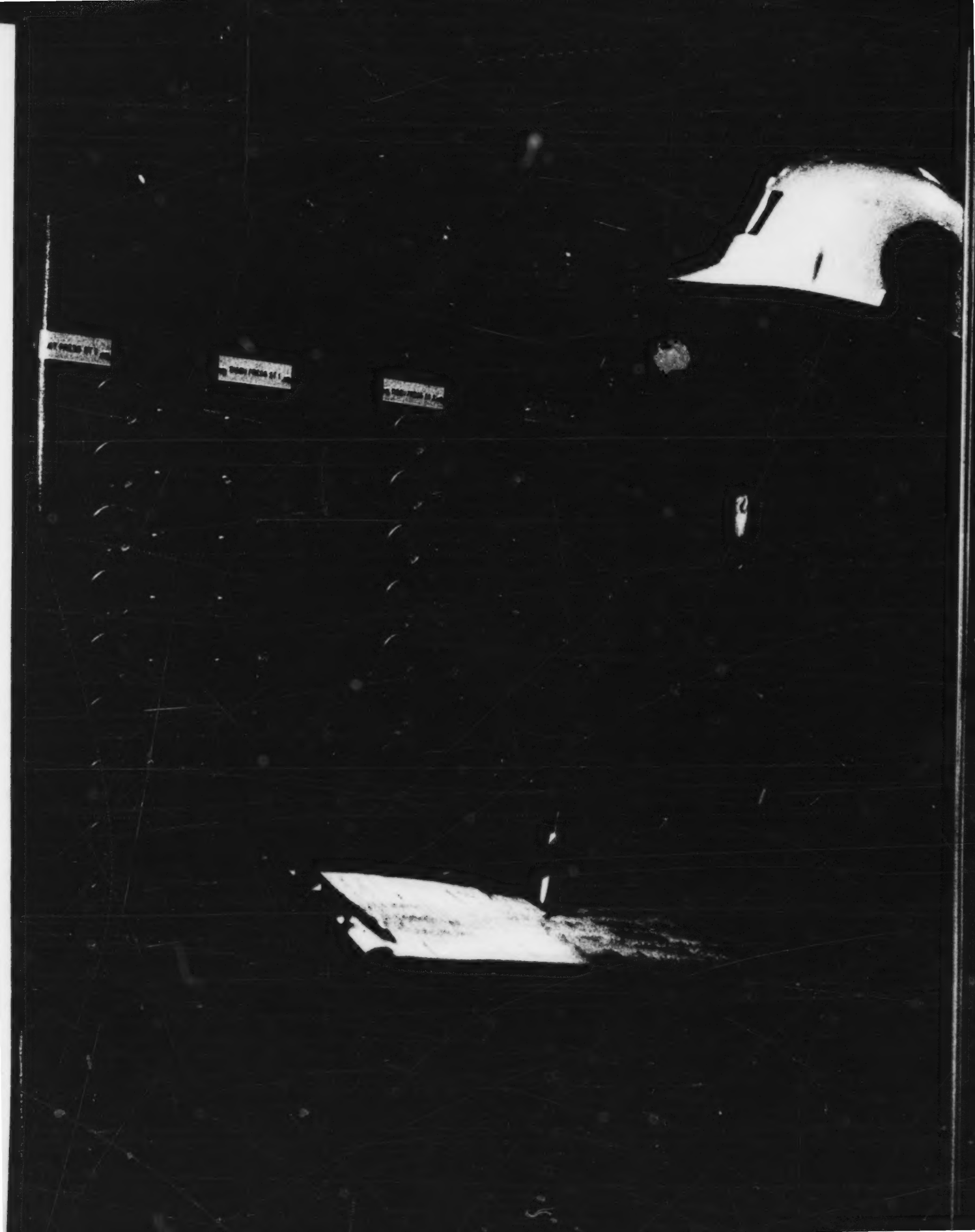
In keeping with the objective to become increasingly selective in our choice of sites for enhanced recovery projects, AOSTRA commissioned a detailed geological analysis of the Pembina reservoir by the Petroleum Recovery Institute. This is the first step toward developing a reservoir model to explain variations in permeability which could adversely affect tertiary recovery schemes. A steering committee comprised of eight resource companies was formed to assist AOSTRA and PRI in the performance of the work. A report on the project is now available.



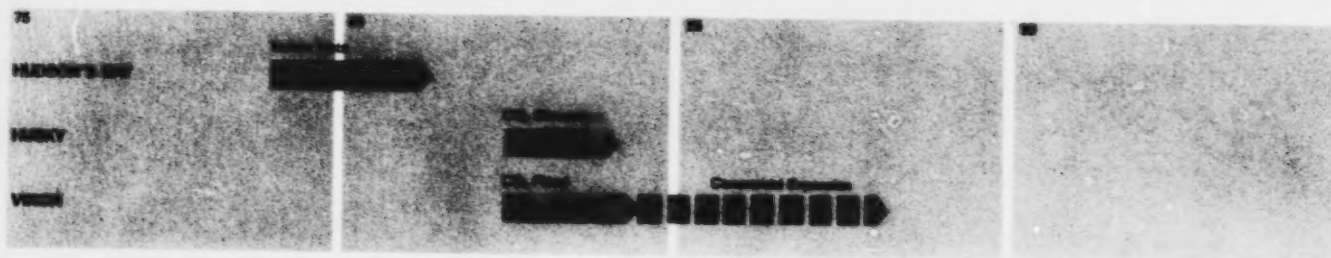
Thermal

The development of technology for enhanced recovery from conventional light oil reservoirs was added to AOSTRA's mandate in 1980. However, even before this change, AOSTRA had launched general thermal enhanced recovery projects in conventional heavy oil reservoirs at Wainwright and Suffield.





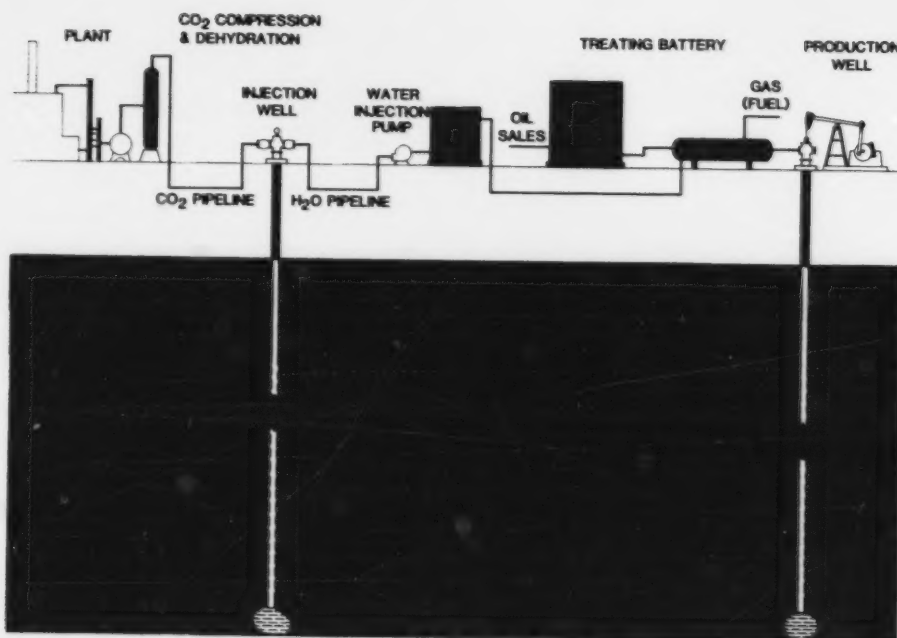
Projected timing of commercialization of the AOSTRA non-thermal projects



Non-Thermal

The first AOSTRA-funded field project in non-thermal enhanced recovery of light oil was started in the abandoned, waterflooded Joffre-Viking Pool in June 1983 in association with Vikor Resources Limited. The experiment involves a carbon dioxide miscible flood in a sandstone reservoir containing 40°API crude oil. Results to date have been encouraging and Vikor has proceeded with commercial expansion of the project with the drilling of eight wells in 1985. Our technical review team judged the Vikor project an outstanding success and deemed the commercial potential of the technology to be good. This has since been proven correct, as Vikor is proceeding to commercialization and the technology has good potential application for other, similarly-depleted Alberta oil fields.

Pilot Sites



The WAG (Water Alternating Gas) Process as used in the Joffre field involves injecting CO₂ well above the minimum miscibility pressure to mobilize the oil in the reservoir and then

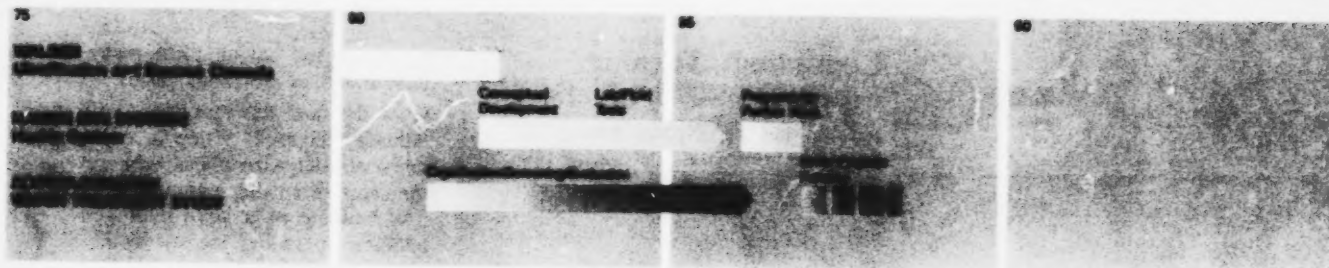
alternately injecting water to reduce gas channeling, enabling the miscible CO₂ to contact a large portion of the reservoir.

The quantity of good quality water required for steam-based in situ processes is five to seven times the volume of oil produced. To reduce the amount of make-up water required for these processes, every effort must be made to clean and recycle as much of the produced water as possible. Many steps are required to bring produced water up to boiler feed quality.

Our objective has been to simplify existing water treatment systems or to introduce new and more cost effective methods of treatment into the system. Some of the treatments tested have included reverse osmosis, ozonation, membrane filtering, submerged combustion, and electrodialysis.

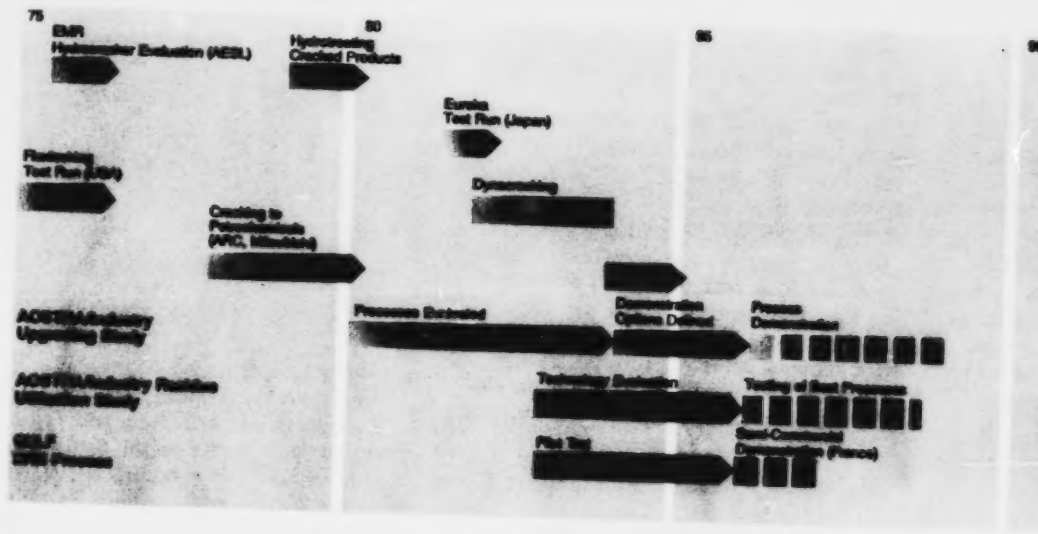
Unfortunately, most treatments have proven too expensive for commercial use, so the search for low-cost solutions to water treatment problems continues. To date, our studies have involved the active participation by suppliers and users, and we plan to continue such cooperative efforts until the objective is met.

Of the six projects undertaken in this group of tests, the technical review team concluded that four were well-defined, but they had concerns about the value of the other two. These two had already been dropped as active projects by AOSTRA, but work will continue in an effort to solve this complex problem.



Schedule for reaching the objectives of developing and testing improved processes for upgrading Alberta heavy oils and bitumens

Bitumen/Heavy Oil Upgrading



Upgrading: Turning Bitumen into Synthetic Oil

Industry has participated with AOSTRA in a comprehensive analysis of upgrading processes which are not in use in commercial oil sands plants and many of which are developmental. As just one result of this study, the advantages of the hydrogen addition processes over the coking processes are now more widely accepted. Industry now shares the objective of demonstrating these

processes and having them ready for the next round of oil sands plants.

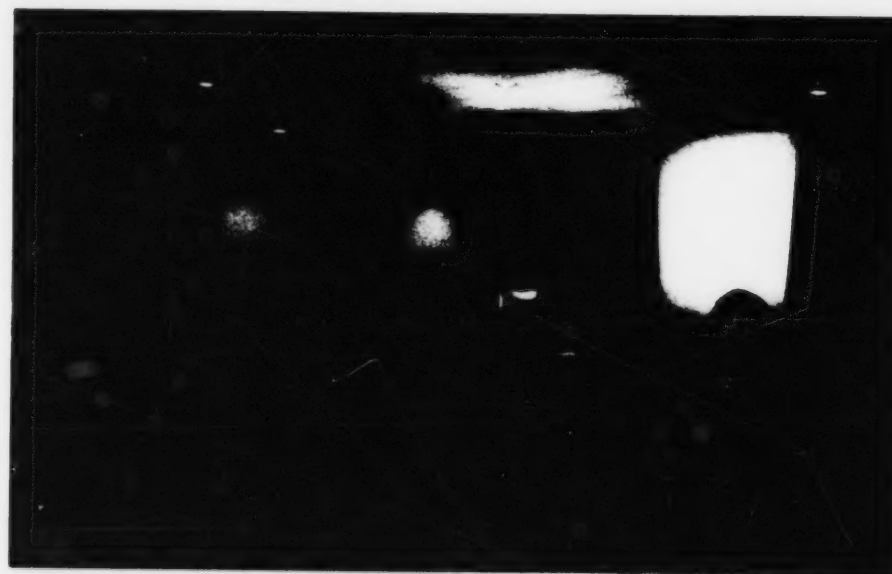
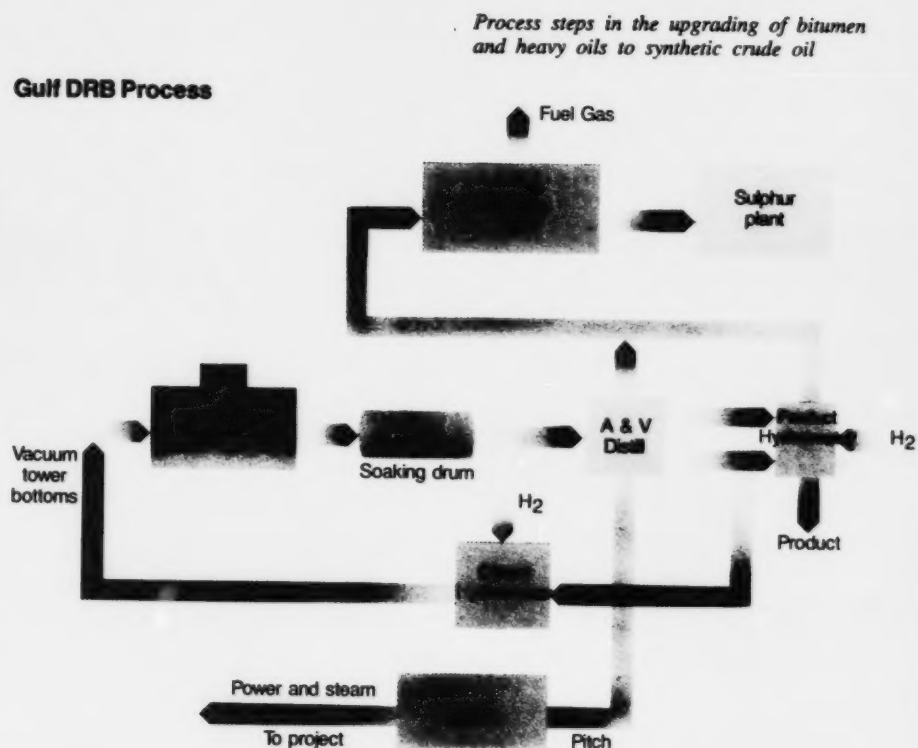
Over the next ten years, we will see Alberta feedstocks tested in existing demonstration size plants with several of the most promising upgrading processes. The building of a large hydrogen addition upgrading facility in the province also seems probable. The history of the AOSTRA program and its future plans are given in the diagram above.

Improved Upgrading of Bitumen

This is one of AOSTRA's major objectives. The review team considered the mandate and objectives of ten of the twelve projects in this area of activity to be well defined. Several of the projects will continue and it is likely that the overall program objective will be met.

AOSTRA has recently acquired an interest in the Donor Refined Bitumen (DRB) Process developed by Gulf Canada Resources Inc. The Process is presently being demonstrated at the ASVAHL experimental refinery in Lyon, France.

Gulf DRB Process



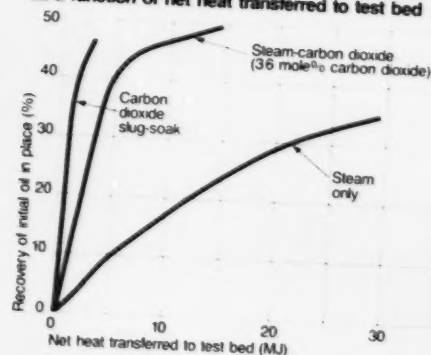
Meetings of all participants are an essential part of AOSTRA's approach to solving problems in upgrading and water treatment

In conjunction with our major expenditures on field pilots to test new potentially viable commercial processes, AOSTRA screens new concepts and conducts laboratory-scale experiments at government laboratories and at universities throughout Canada.

We also support research on the basic properties of natural resources, and are delving into the reactions taking place by observing the mechanisms under controlled conditions in both physical and mathematical simulations.

With a few exceptions, our technical reviewers judged the performance of the various research groups as being good to excellent. The Alberta Research Council, as would be expected with a multidisciplinary and dedicated staff, conducted a well-planned, well-executed research program for AOSTRA. The performance of the diverse university projects was mixed. Ratings ranged from excellent to poor, with the majority deemed satisfactory or above.

Comparison of recoveries for combined cyclic and slug-soak cyclic steam-carbon dioxide processes as a function of net heat transferred to test bed

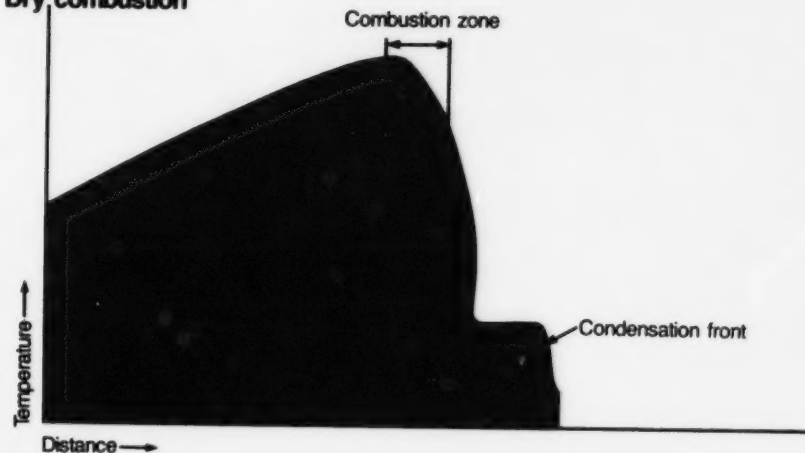


Results from three experiments using Alberta Research Council physical simulators

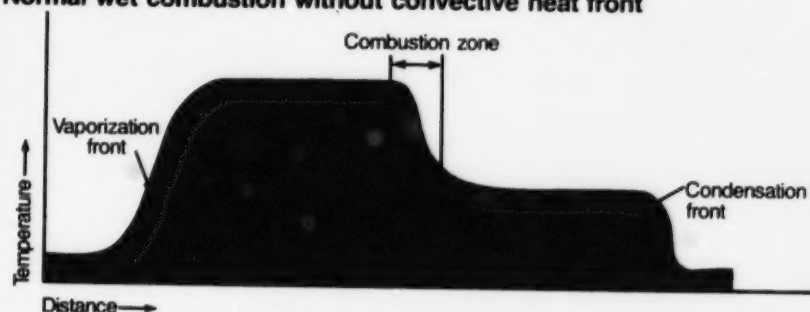


Measurement of CO₂ diffusion

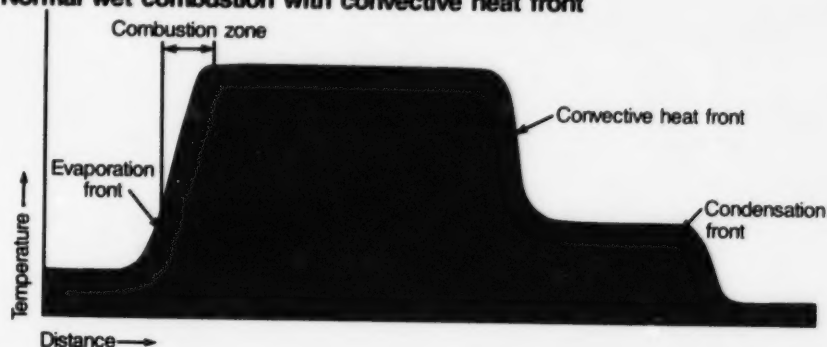
Dry combustion



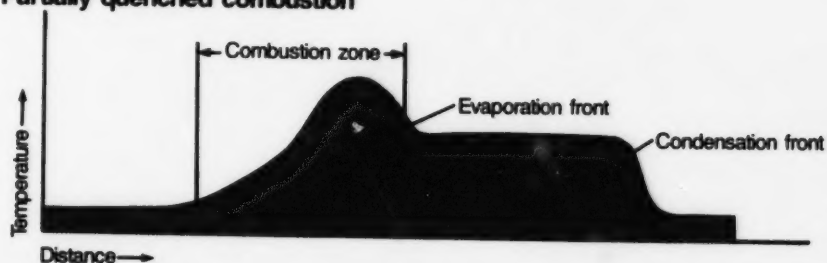
Normal wet combustion without convective heat front



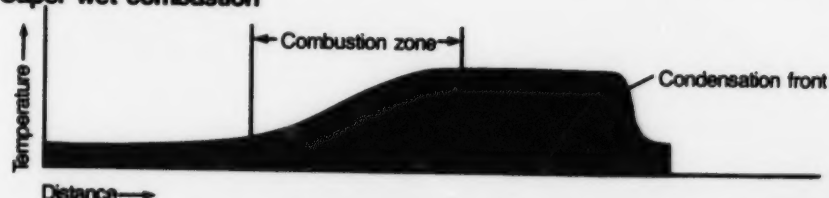
Normal wet combustion with convective heat front



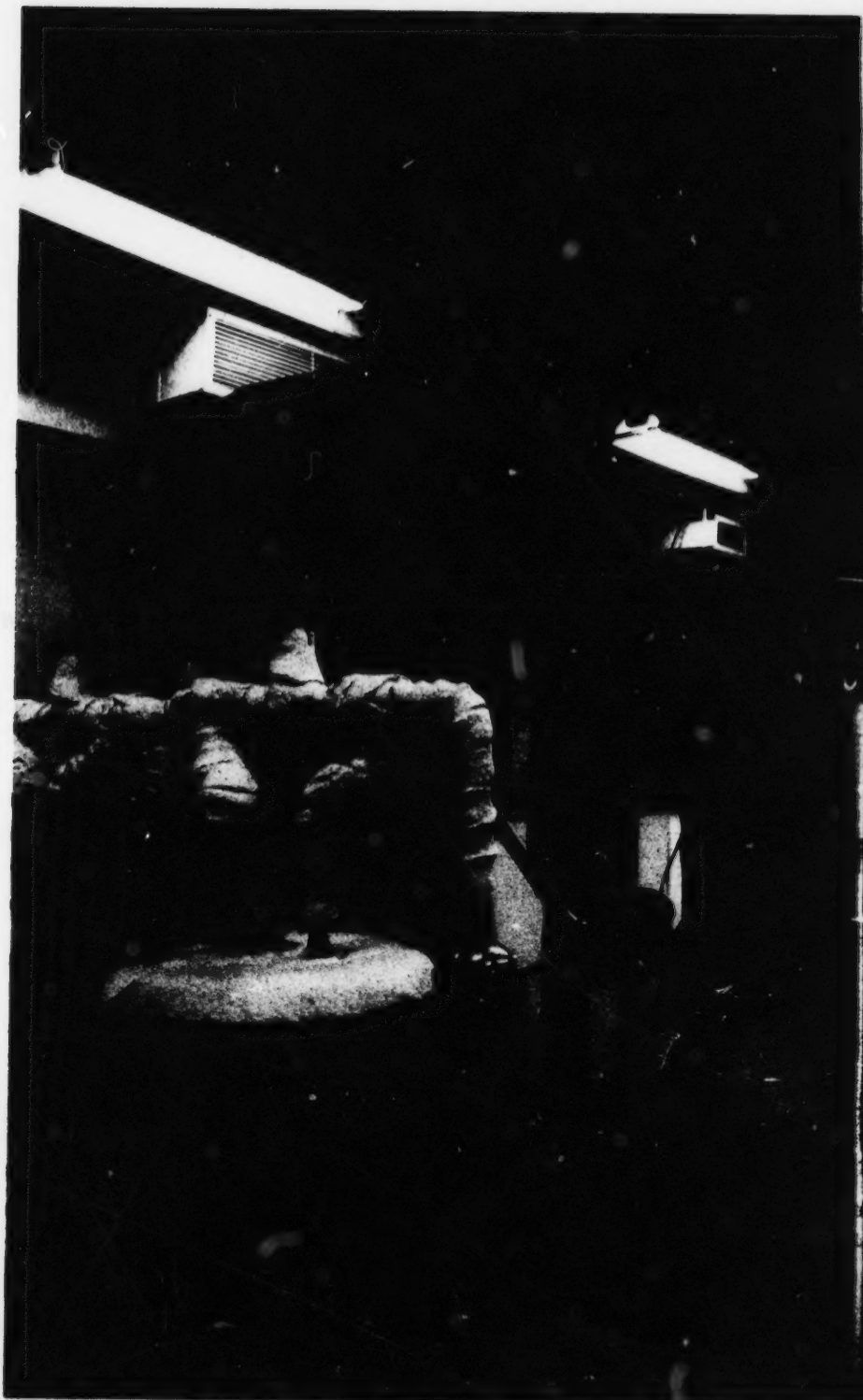
Partially quenched combustion



Super wet combustion



Just one aspect of the institutional program is the combustion tube project at the University of Calgary. Here, the reactions and conditions of in situ combustion processes are simulated and analyzed by highly-sophisticated measuring equipment. Only by such direct observations, under controlled conditions, of the basic phenomena will we be able to design meaningful field experiments.



Bitumen Chemistry

By identifying the components of bitumen, and by separating and studying their structures, we are attempting to open up new paths for upgrading, and find new methods that will be superior to the thermal cracking and hydrogen addition processes now used for the upgrading of bitumen and heavy oil.

During the past nine years, AOSTRA has funded research on the chemistry of bitumen at the University of Alberta Hydrocarbon Research Center and at other Canadian universities. Much good-quality fundamental data has been generated and published. Over the next ten years, we should see this fundamental data applied to developing low-temperature catalytic processes which break molecules into the smaller sizes needed to produce lighter refinery products required by the marketplace.

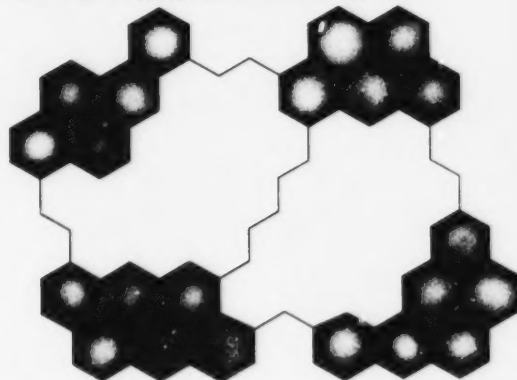
Much attention has been focused on the asphaltene fraction of the bitumen.

Dr. Otto Strausz and his colleagues at the University of Alberta have made great strides toward understanding this important component of bitumen.

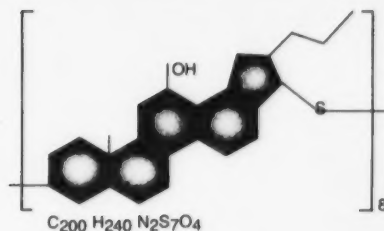
Large polynuclear aromatic systems



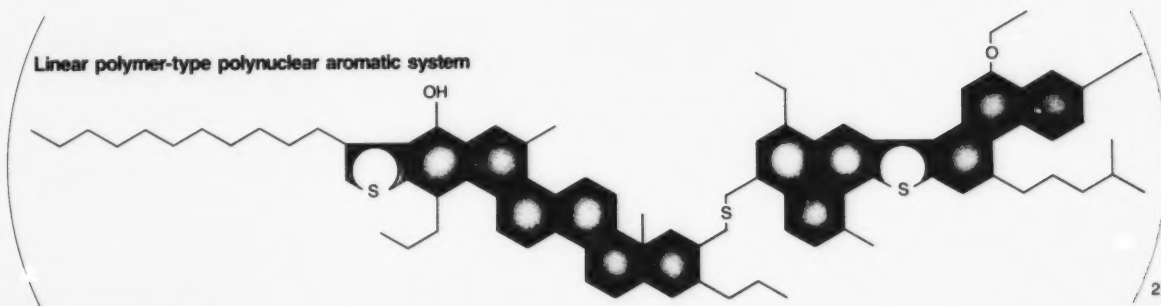
Smaller (linked) polynuclear aromatic systems



Average hypothetical asphaltene molecule



Linear polymer-type polynuclear aromatic system





Professor Tollefson's coke desulfurization laboratory at the University of Calgary

Upgrading Residue Utilization

When bitumen and heavy oils are upgraded, the yield of light oil products increases. Unfortunately, upgrading processes also produce a residue stream in the form of coke or pitch in which the metals, ash, and much of the sulfur present in the bitumen feed are concentrated. The challenge is to utilize these residues in a manner which is both cost-effective and environmentally acceptable.

AOSTRA and industry partners are examining methods which will enable us to meet this challenge. Candidate technologies include conventional and fluidized bed and combustion for steam and power generation, gasification to fuel gas, and manufacture of synthesis gas.

Basic work on the combustion mechanisms in fluidized beds is also being studied extensively in the Department of Chemical Engineering at the University of Calgary and elsewhere.

Surface and Interfacial Chemistry

Understanding the activities that occur where oil, water, and solids interface is basic to understanding the bitumen/sand separation processes and the flow of fluids through porous media. New discoveries have been made in this field by researchers at the Alberta Research Council and at universities across Canada. The practical importance of these advances lies in our understanding of the microhydrodynamics of wetting and displacement processes. In the near future, these advances will be evident in improvements in the design and operation of the aqueous bitumen recovery processes and in the understanding of mechanisms of flow in thermal in situ processes.

Mechanism of Bitumen Displacement

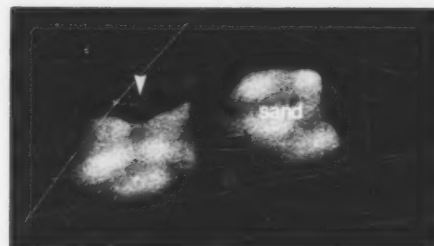
(a) The water wet Athabasca sand grains are surrounded by a very thin layer of connate water (not shown) which, in turn, is surrounded by bitumen.

(b) As water is added (aqueous phase) to the system, the bitumen layer between the aqueous phase and the connate water thins.

(c) Further addition of water causes the bitumen membrane to rupture, thus mixing the aqueous phase with the connate water allowing the bitumen to peel back from the sand grains.

(d) The bitumen concentrates as globules between the sand grains because the smaller bitumen-water interface represents the more thermodynamically stable state. Small globules may be left isolated as indicated in the diagram.

(a)



(b)



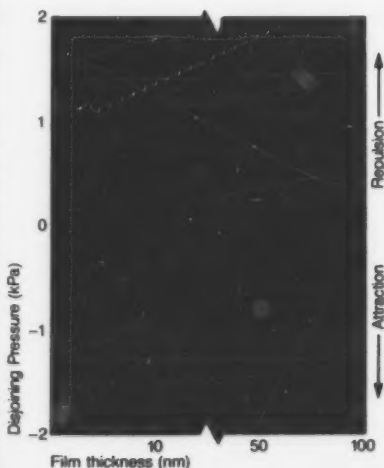
(c)



(d)



(a) Calculated disjoining pressure (π) of water between sand and bitumen for various compositions.



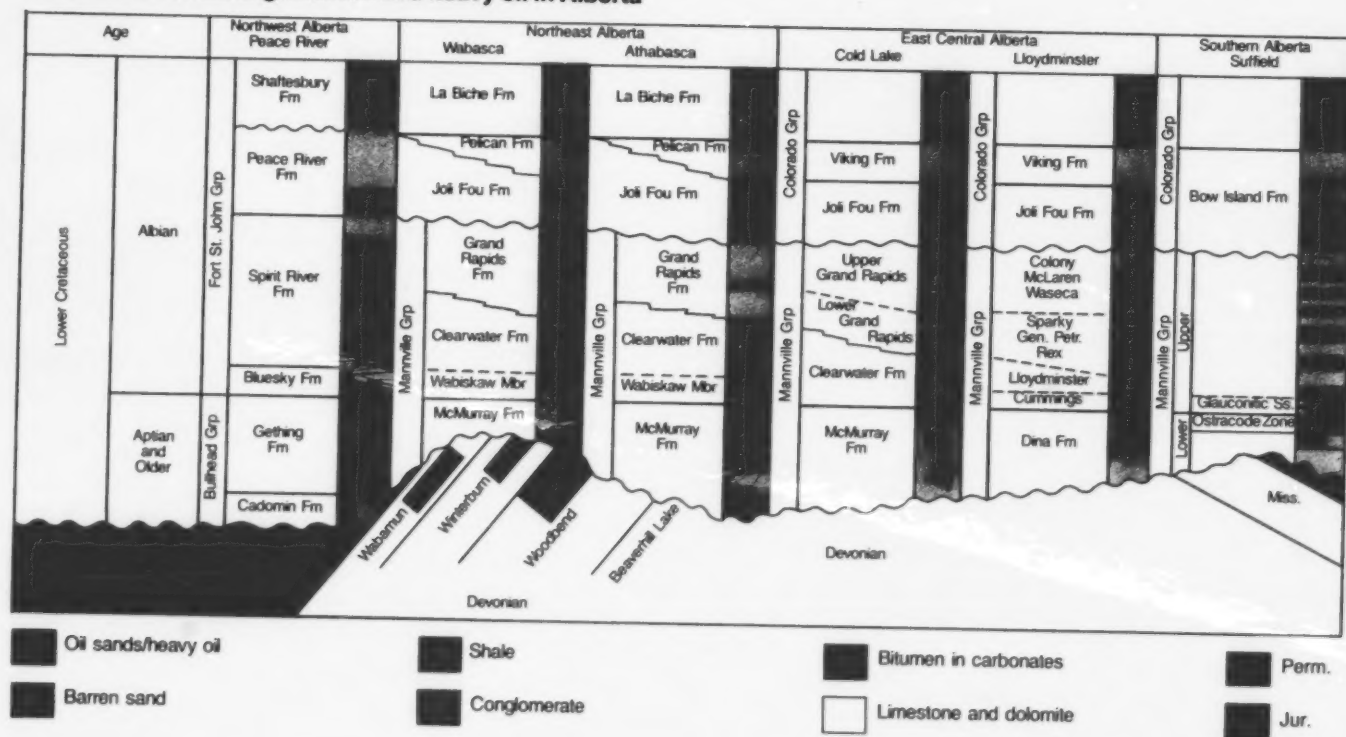
(b) In a sodium hydroxide solution, the double layer repulsion acts together with the capillary forces resulting in high receding film velocity; i.e. the film on rupture, snaps back from the sand surface.



(c) In a calcium chloride solution, the van der Waals attractive forces are large and lead to contact between the bitumen and the sand, thus opposing the action of the capillary forces and resulting in low receding velocities.



Formations containing bitumen and heavy oil in Alberta

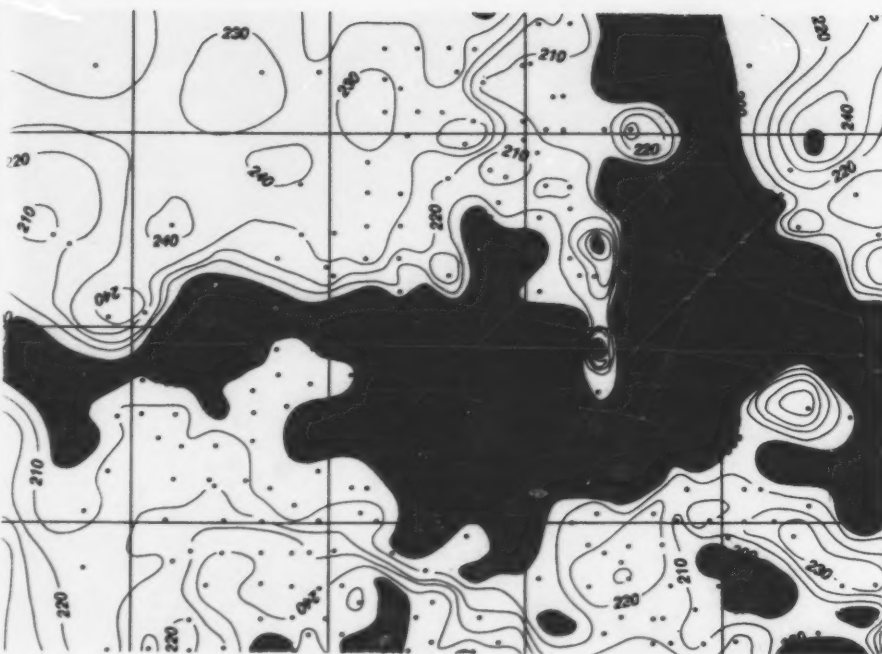


Geology

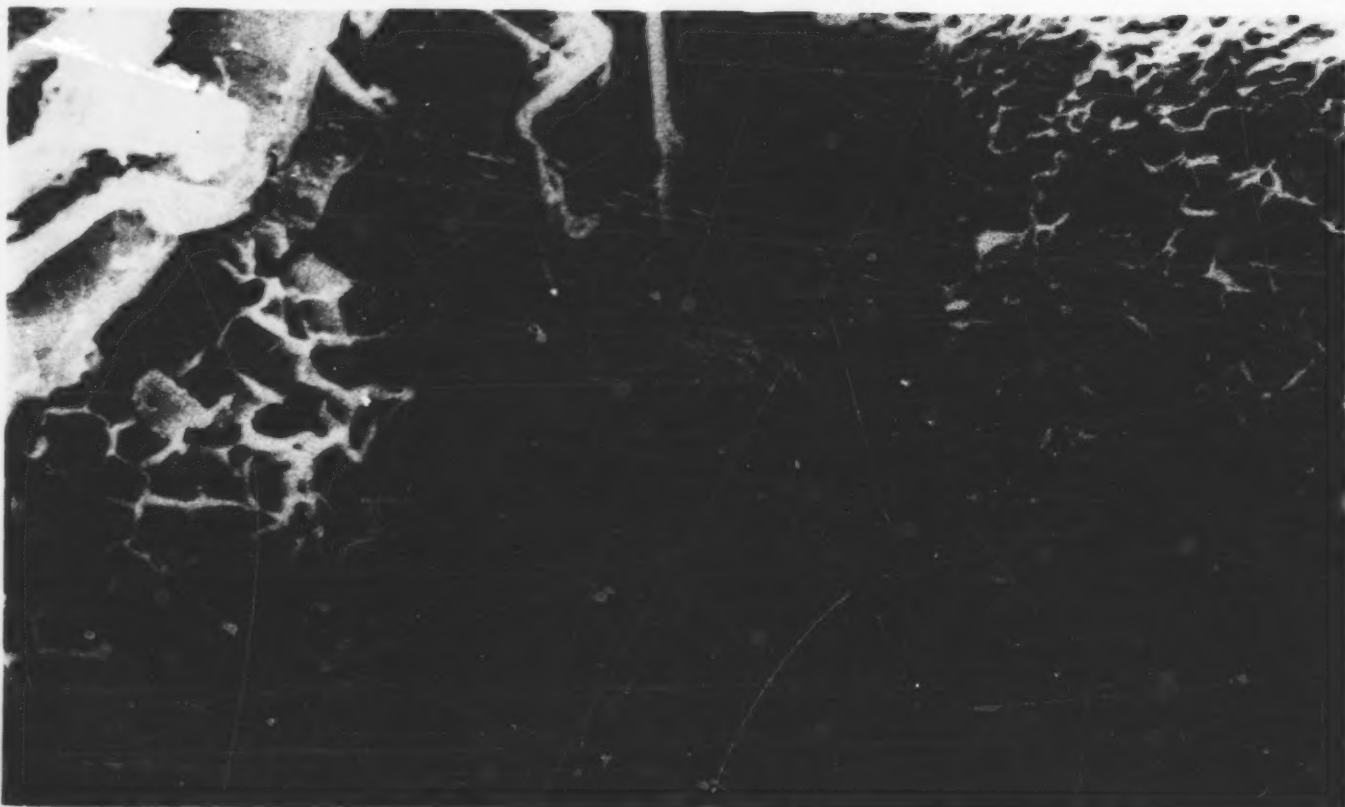
Detailed geological information is vital to the success or failure of in situ processes and advanced enhanced recovery methods. The more sophisticated the recovery scheme, the more detailed the geological and reservoir knowledge required to make it work. A successful pilot project usually requires a good understanding by the engineers of the reservoir, its structure and the existence of any major heterogeneities that will affect the flow paths of the fluids.

Experience over the past ten years has convinced AOSTRA that geology is an essential part of this information system and much more attention and time must be put into this aspect. This is another

of the recommendations of the review team that has been adopted by AOSTRA and will, in future, be done before the process design is finalized. To date, AOSTRA has expected the participating companies to provide geological descriptions for their own pilot sites. Much of the geological work funded by AOSTRA has been performed at the Alberta Research Council by the Alberta Geological Survey and has been concerned with regional mapping. The type of geological data that will be required to operate pilots in the future will involve much more intensive laboratory work on the reservoir rocks and their petrographic properties, rock-water interactions, identification of the nature and extent of permeability barriers, and high permeability thief zones.



*Typical structure
contour map*



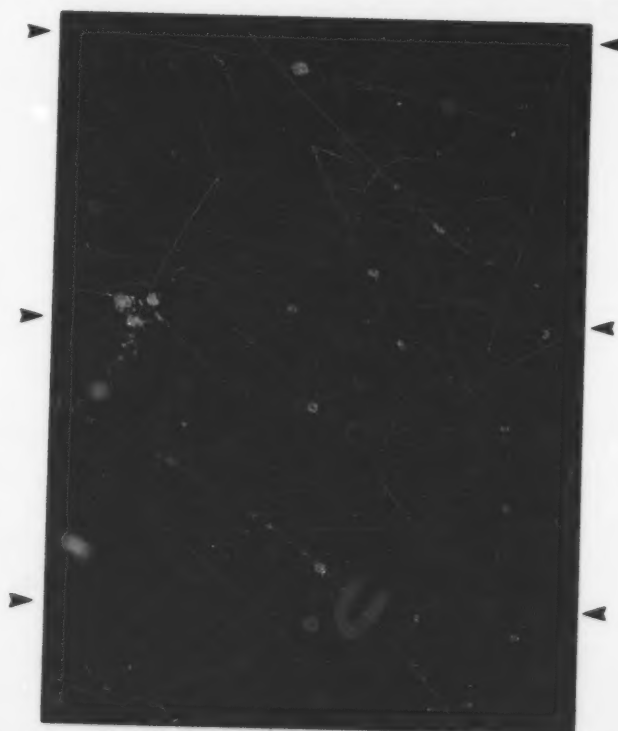
*Scanning electron micrograph of mineral growth
in a rock pore as a result of thermal recovery*

Fluid Rock Interactions

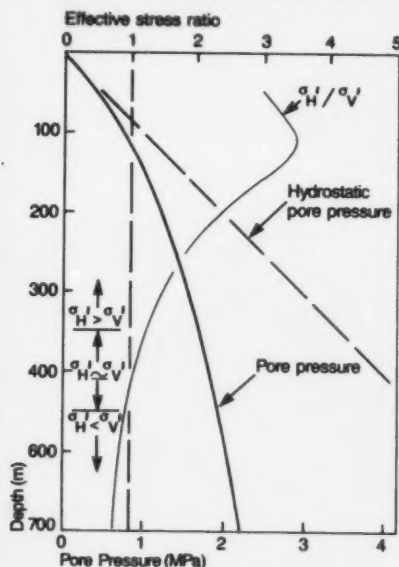
When hot fluids are injected into the reservoir to lower the viscosity of the bitumen and promote its recovery, they not only interact with the reservoir fluids but also with the rock matrix, dissolving it in some parts of the formation and depositing it in others.

On a microscopic level, the reaction of the fluids with the rock matrix can be an important factor in the flow of fluids and should be evaluated. This requires a good description of the mineralogy of the reservoir rocks and knowledge of the temperatures, pressure, and chemistry, and rates of flow of the injected and produced fluids as they travel through the pores of the rock.

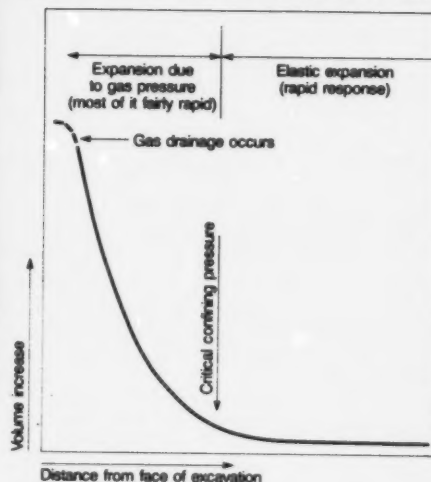
Mineral dissolution and transformation



Ratio of horizontal and vertical stresses with depth in Athabasca Oil Sands



Expansion of oil sand on stress relief

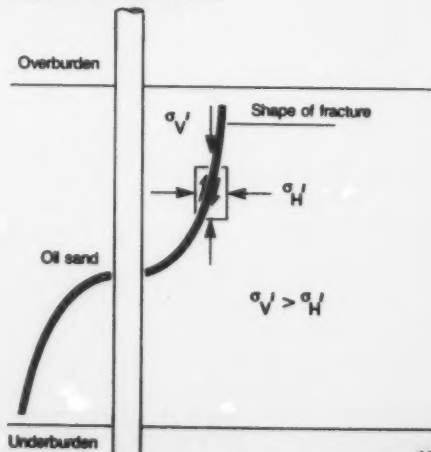


Geotechnical

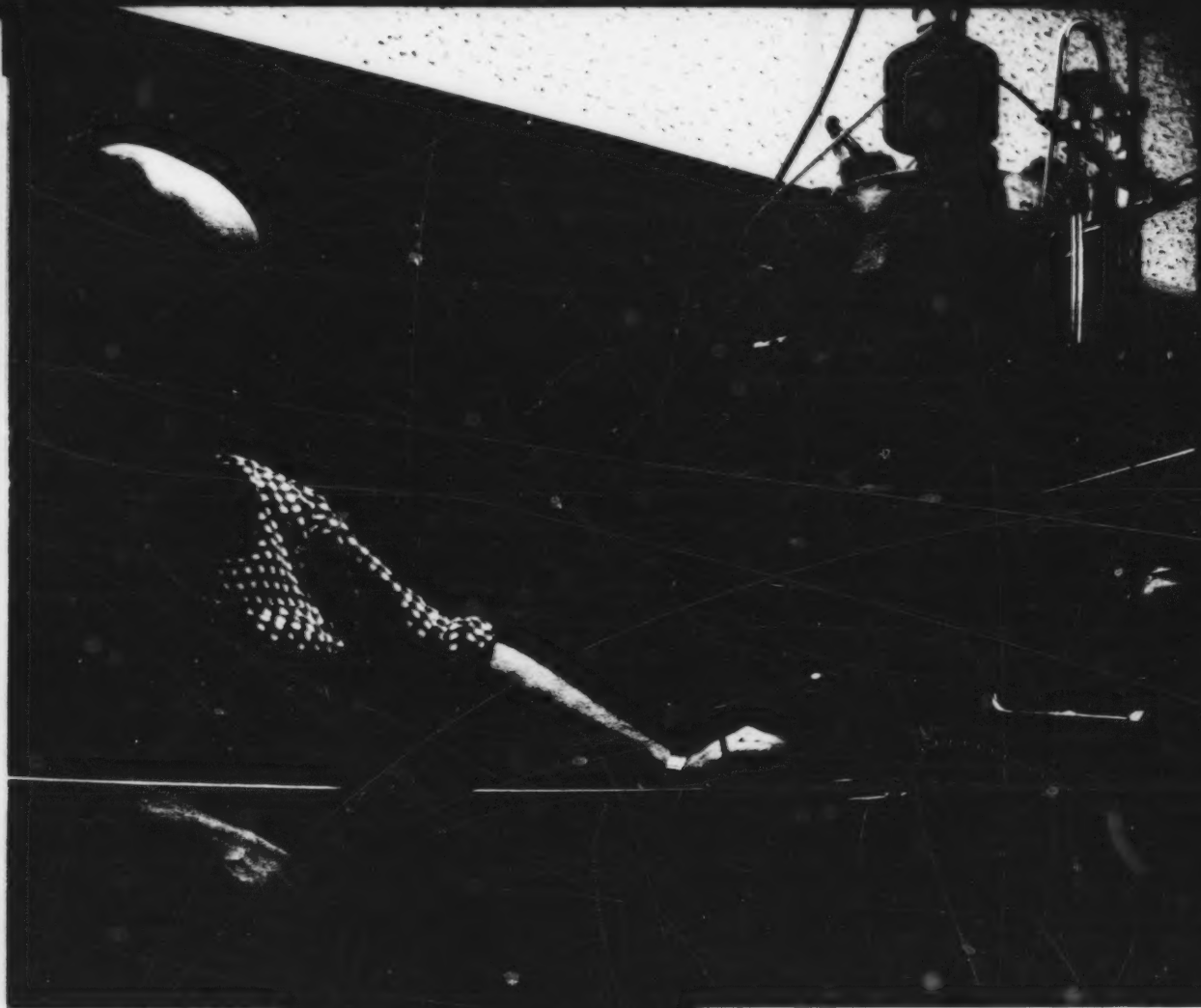
A knowledge of geotechnical properties of oil sands from the stability of mine faces in the Athabasca deposit, to fracturing which occurs when fluids are injected into the formation is essential to the engineering of successful projects.

AOSTRA professors at the University of Alberta have been analyzing and measuring the magnitude of stresses caused by heating oil sands and the resulting effect on the propagation of fractures. Equipment has been specifically designed and constructed to study the geotechnical properties of oil sands at reservoir temperatures and pressures. The properties now being measured are providing valuable new insights on the behavior of oil sands under a wide variety of temperatures and pressures not normally measured in geotechnical laboratories.

Propagation of fractures under initial formation stresses



Professor Scott in his geotechnical laboratory at the University of Alberta



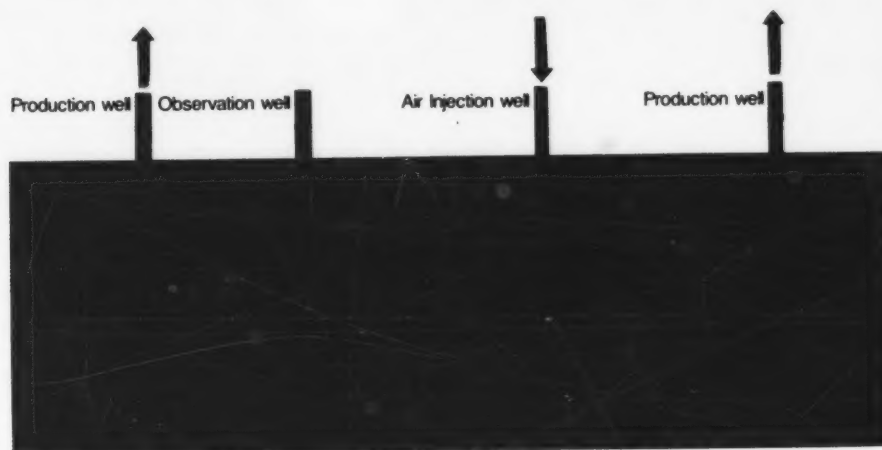
CAT (Computer Assisted Tomography) scanning has long been used in the medical field to give a cross section image of the human body. Alberta Research Council researchers are now using it to study variations in fluid flow during the thermal recovery of bitumen from oil sands samples.

Physical Parameters

To understand the processes needed to extract oil and bitumen from their natural surroundings, and to mathematically model these processes in order to predict the reservoir fluids under all conditions of temperature and pressure, a number of fundamental physical parameters are required. These include: viscosity, relative permeability, pressure-volume temperature relationships, capillary pressure, and mass and heat transfer coefficients. To obtain this fundamental data, a well equipped laboratory has been set up by AOSTRA in cooperation with the scientists and engineers at the Alberta Research Council.

This program has designed unique equipment which operates under high temperatures and pressures resulting in the establishment of a valuable data base. The technical review team rates this project very highly.

Detection of seismic events generated by a combustion process



Heated zone Seismic events Geophone

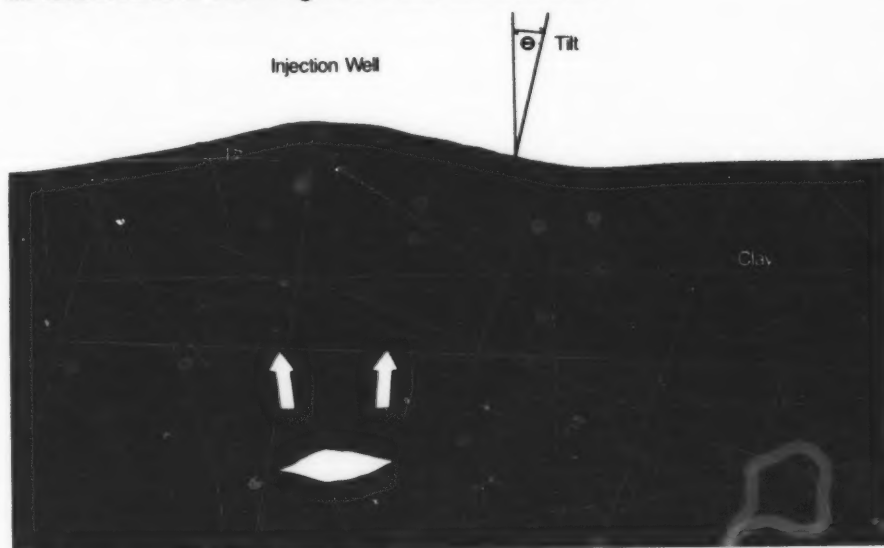
Remote Sensing

For many people, the term "remote sensing" still belongs in the realm of science fiction. However, the ability to monitor conditions from vast distances – even when those conditions are hidden beneath the earth's surface – is present today.

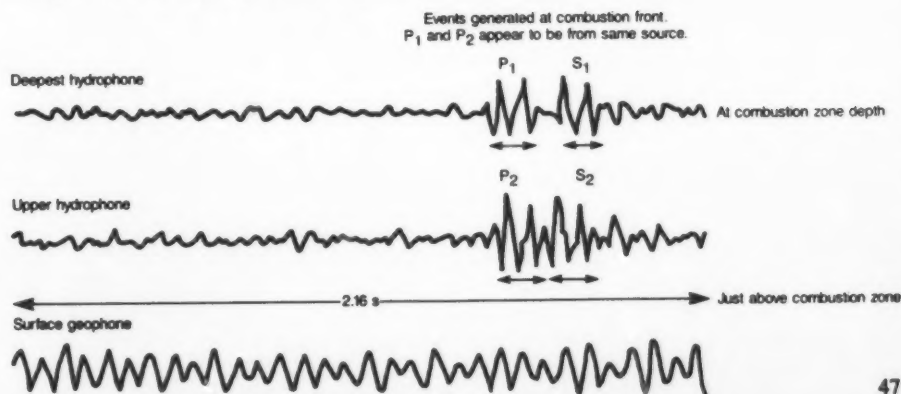
In our industry, remote sensing technology is used to measure changes in temperature and volume which occur when thermal processes are applied to underground reservoirs. To locate advancing thermal fronts at our in situ pilots, AOSTRA has used such instruments as tiltmeters, observation wells, high frequency seismic sources and detectors, passive seismic detectors, and magnetotelluric detectors.

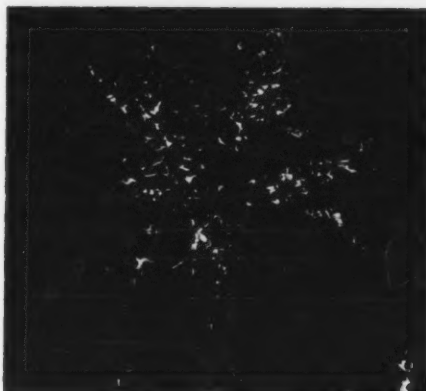
While our success in the area of remote sensing was rated only fair, performance can only be as good as the equipment and techniques available in the industry. AOSTRA agrees with the technical review team's recommendation that this technology requires further development. The successful identification of the size, shape, and rate of advance of the heat front, obtained from surface observations, would signal a significant advance in the control and production of reservoirs. This would, for example, facilitate optimal operation of the injection and production wells leading to rapid and improved recovery of the resource.

Surface lift and tilt resulting from a horizontal fracture



Geophone and hydrophone traces from a fireflood





Air monitoring facility



Lichen plots similar to this are used to determine whether sulfur emissions have any long-term biological effects

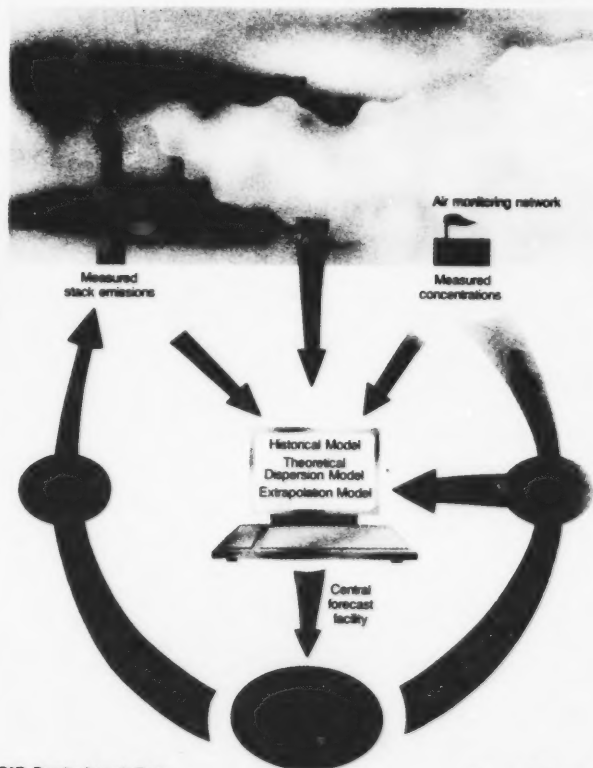
Every commercial plant or experimental pilot put into operation produces some impact in the natural environment. The developers and users of technology have a responsibility to keep that impact to a minimum. The first steps in achieving this objective are to be aware of the natural eco-system, and to be sensitive to the consequences of the introduction of new technology.

AOSTRA has always maintained that the technology we develop must be environmentally acceptable. Our efforts have been aimed at ensuring that any process we support financially does not discharge large volumes of waste particulates, chemicals, or liquids that cannot be handled within the regeneration capacity of the local eco-system.

Testing of process streams for toxicity and carcinogenicity has been performed on all processes now in development, and mitigation research has been funded

where potential problems have been identified. Long-term research on the effects of SO_2 vegetation have been carried out by an AOSTRA professor at the University of Lethbridge. Development of air quality prediction systems has been started in collaboration with Syncrude. Identification of toxic components has been funded at the University of Calgary and possible carcinogenic substances have been tested for mutagenicity at the University of Alberta and the British Columbia Cancer Institute.

AOSTRA remains committed to development of environmentally acceptable technology and will continue to fund projects that will assist with the identification and mitigation of hazards generated by AOSTRA-funded technology. In addition to those projects directly related to environmental concerns, AOSTRA always reviews each application for any adverse environmental implications.



DAR: Doppler Acoustic Radar
 AES: Atmospheric Environmental Service
 AOSERP: Alberta Oil Sands Environmental Research Program
 SEAD: Syncrude Environmental Affairs Department

Air quality prediction system being developed for oil sands plants in collaboration with Syncrude Canada Ltd.



Technology Transfer

No technical achievement can be called successful until it can be repeated and successfully transferred to another location under a different set of circumstances. The amount of knowledge and manpower required to make these transplants successful in uncontrolled natural environments is often underestimated and the number of successful transfers of technology is fewer than anticipated. The total revenue gained by AOSTRA from technology sales is \$13.5 million. AOSTRA recognizes that the amount of money invested in this vitally important mechanism will have to be proportionately higher in the next ten years than in the past. But, if the past accumulation of data is to be put to useful work, the investment must be made.

International Activities

Technology development, like science, is an international activity. Progress is made more quickly and at less cost when it is tested and developed by a large number of people and applied in a wide variety of situations.

Maintaining an international awareness and a knowledge of the nature of the petroleum resource industry throughout the world is a vital element in the development of viable technology. AOSTRA has endeavored to be aware of all the variations in the occurrence and nature of the resource industry and to assist others to understand and apply the technologies we have developed. To achieve this objective, technology exchange agreements have been signed with many foreign organizations. As these agreements are often the forerunners of trade between Alberta and other countries in the petroleum equipment, engineering, and services industries, they are an important part of AOSTRA's technology transfer program.



AOSTRA visitors at a heavy oil site in the Karamay Oil Field, Xinjiang Province, People's Republic of China

AOSTRA, in cooperation with OMNIS (Office Militaire National Pour les Industries Stratiques) of Madagascar, assisted in the drilling of blast holes to remove a bulk sample of oil sand which was sent to Calgary for testing in the Taciuk Processor

50



Signing of cooperation agreement with Xinjiang Petroleum Administration



Inventors Assistance

The old saying "necessity is the mother of invention" is especially apt in the oil industry. AOSTRA's experience has been that inventions conceived to solve problems arising from theoretical analysis (known in the industry as "paper inventions"), are not likely to be as useful as those which solve "real" problems arising from real life situations.

AOSTRA's Inventors Grant Assistance Program (IGAP) was established to encourage inventors with limited means to obtain patent protection for their inventions or to undertake sufficient evaluation work to secure funds for further development from private funding agencies. The review team deemed this to be a clear, well-defined program with potential major impact. The team's recommendation to provide higher funding is now being considered by AOSTRA.

Most of the inventions submitted for funding under this program to date have been in the oil field equipment area. The program promises to be particularly useful to entrepreneurs who require a little "seed" money to obtain the recognition and patent protection needed to start a successful manufacturing operation.



The development of the Pulsar mud hammer was assisted by an IGAP grant from AOSTRA

Information Retrieval

Over the past ten years, we have seen the beginning of the information era and the rise of the information specialist. The treatment of information as a commodity is not necessarily a progressive step. Information is valuable only if it is relevant, if it contributes specifically to the solution of a problem, or prevents the duplication of work already done.

Unfortunately, most technological information in the public domain is generalized and the quality of data generated during the economic boom years has not matched its quantity. The need now is not to increase the size of the system to handle all of the information being produced, but rather to design a system that selects the good information from the bad.

AOSTRA has developed systems for collecting, storing, and retrieving information published on the oil sands. We have made this service available on a subscription basis to all interested parties through our support of the Oil Sands Information Center, which is operated and staffed under contract by the Alberta Research Council. In the next ten years, the challenge for AOSTRA will be to collate, summarize, and sort the data in this massive information base, making it accessible to users.

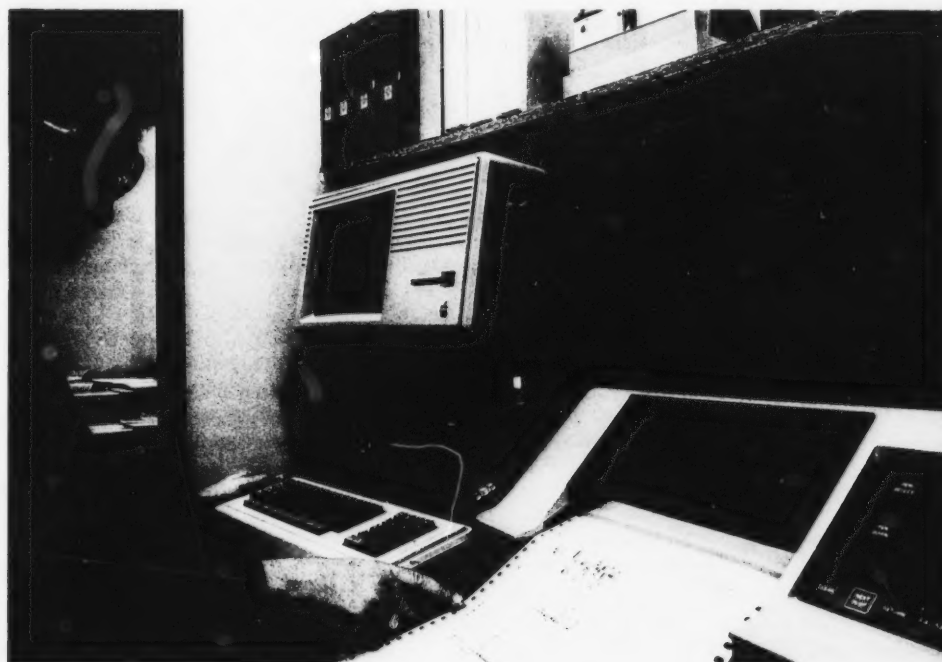
■ Government
 ■ Educational institutions
 ■ Industry
 ■ Foreign
 1982-83

Classification of subscribers by organizational type

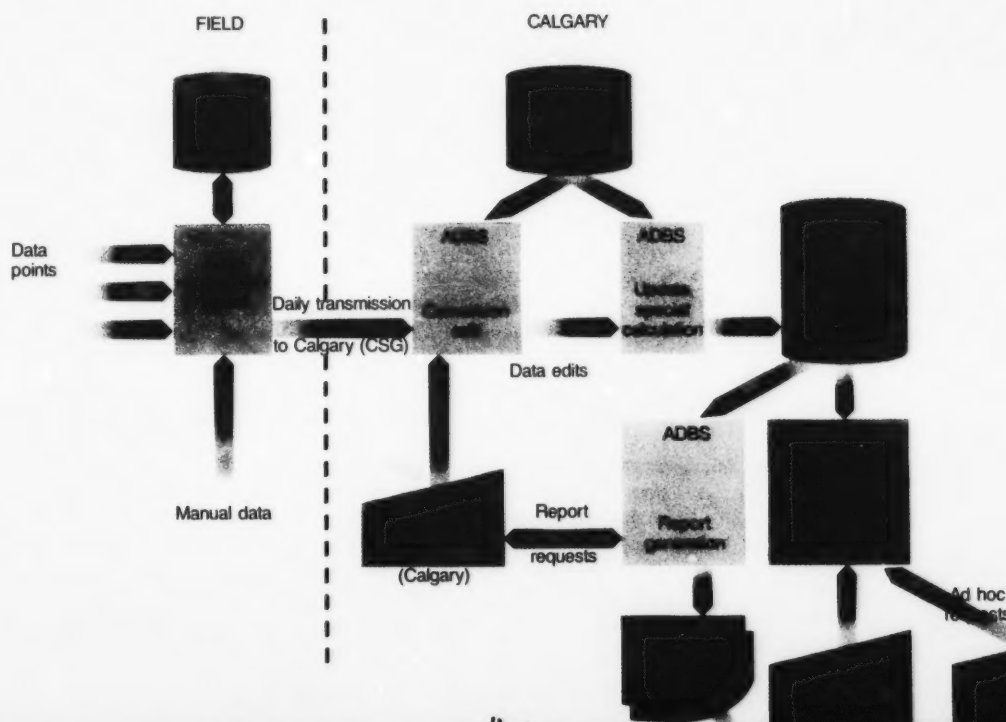


Management of Data

Each AOSTRA field pilot project is heavily instrumented and produces millions of pieces of data. As these must be stored and retrieved by a large computer system, AOSTRA has developed a *Data Base Management System*. The system has been refined over the past ten years and is now operated at a Calgary Service Bureau. The next improvement needed in the system is to make selected portions of the data from all pilots available to engineers and scientists, who can manipulate data on the small, powerful office computers now widely available. With the increasing memory capacity of the small computers, specialized software packages can be developed by AOSTRA to enable engineers and scientists to readily analyze, and compare the process mechanisms in the many AOSTRA pilots. The technical review team concluded that the ADBS is operated effectively and efficiently, but noted it is dated and requires modernization. AOSTRA has accepted this recommendation and has taken steps to update the system to meet future requirements.



Project data flow



Letter from the Technical Audit Steering Committee

June 21, 1985

Mr. R.D. Humphreys - Chairman
and Members
Alberta Oil Sands Technology and
Research Authority
500 Highfield Place
10010 - 106th Street
Edmonton, Alberta
T5J 3L8

Gentlemen:

We have completed a technical audit of all projects and programs undertaken by AOSTRA from its inception in 1975 to projects formally authorized before July 30, 1984 in accordance with Terms of Reference, dated December 19, 1983. The attached report outlines the scope of the audit, the methodology used in reviewing the projects, and the general findings of the auditors.

In order to ensure the free and unfettered criticism of its projects, programs, operating partners, and researchers, AOSTRA has agreed to keep the comments of its auditors strictly confidential.

We believe it is the responsibility of the Steering Committee to balance the specific criticisms of individual audits with the overall achievements of AOSTRA over the ten-year period of its existence and in this context have reviewed the Authority's record in relation to the purposes set out in the Act establishing AOSTRA.

One objective was to establish an in situ recovery process for each major oil sands reservoir in Alberta. AOSTRA has funded pilots in all of the major deposits and today commercial operations are underway in two of these deposits based on AOSTRA-sponsored pilots.

Another goal was to develop more effective, efficient, and environmentally-acceptable upgrading technology. This has not been achieved, but considerable progress has been made in identifying the technologies that are available in industry. A thorough analysis of the suitability of these processes to the Alberta feedstocks has been completed with the full cooperation of industry. The Steering Committee believes that the effort on this objective has been appropriate and that the groundwork has been adequately laid for the next phase, which is to demonstrate that the processes available are economically viable and environmentally acceptable for Alberta feedstocks.

The resolution of major technical problems of current surface mining technology is an area of AOSTRA concern. The problems include the need to store and handle the vast quantities of sludge and effluent from the hot-water process; the poor recovery from lower grades of oil sand; and the need for a mining system to handle the overburden more cheaply and effectively. AOSTRA has funded research in all of the problem areas and has made significant progress in some. The Steering Committee believes the efforts of AOSTRA in achieving this objective have been appropriate and need to be continued until at least one dry tailings process is demonstrated.

Another objective has been to seek increases in percent recovery for in situ processes. This was to ensure that the processes chosen for in situ recovery funding are not just achieving high well productivity and early returns, but will also result in a high ultimate recovery of the resource. The Steering Committee believes that AOSTRA has kept this objective in mind in choosing in situ processes and has made the industry aware of its responsibilities in this matter so pilots will be operated long enough to prove their ultimate recovery potential.

Another area of activity has been to encourage development of an alternate surface extraction technology. To date no breakthrough has been achieved, but encouragement has been noted in the development of a recovery system producing dry tailings.

The conversion of oil sands and heavy oils into higher valued petroleum and mineral products remains a long-term goal. A modest amount of work has been carried out on a direct conversion of bitumen to petrochemical feedstocks. One operator and several research projects are being funded through Canadian universities, providing some hope that this objective might be achieved in the foreseeable future.

An active program of institutional research has been sponsored, significantly raising the level of basic and applied research being conducted in Canada and particularly Alberta. A number of projects are based on consultation with industry/universities and government research groups and are contributing to a growing base of knowledge regarding heavy oil and bitumen characteristics and recovery mechanisms.

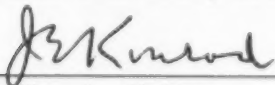
As a result of the wide range of activities supported, AOSTRA has become the repository for technical data related to the various projects. Services are offered to industry and others enabling this data base to be accessed. A world renowned oil sands and bitumen sample service is also sponsored.

As a result of work sponsored, AOSTRA holds patents and licensing rights to a growing number of processes. Sales of technology exceeded \$13 million by early 1984.

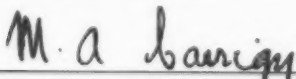
AOSTRA-sponsored seminars and international exchanges have brought world wide recognition to the organization as a leader in the development of oil sand technology.

The Steering Committee has concluded that the overall performance of AOSTRA has been more than satisfactory and that the Authority should continue to pursue its mandate. Some changes in emphasis have been recommended in the attached summary which deserve serious consideration by the Members.

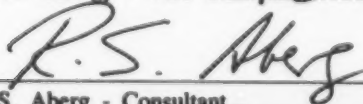
Respectfully submitted
Technical Audit Steering Committee



J.E. Konrad - Chairman



M.A. Carrigy - Vice Chairman AOSTRA



R.S. Aberg - Consultant

Statement of Revenue Expenditure & Fund Balance

Oil Sands Technology and Research Fund
Ten - Year Summary For the years ended March 31

	1985	1984	1983	1982
Revenue				
Alberta Heritage Savings Trust Fund	\$50,000,000	\$54,500,000	\$39,500,000	\$28,500,000
Technology sales	2,056,808	1,988,107	2,876,477	3,477,561
	<u>\$52,056,808</u>	<u>\$56,488,107</u>	<u>\$42,376,477</u>	<u>\$31,977,561</u>

Expenditures

Institutional Research

Alberta Research Council				
— Information Centre	\$ 551,962	\$ 495,183	\$ 438,174	\$ 394,205
— Oil Sands Research Centre	2,915,270	3,236,077	2,877,172	2,369,308
— Sample Bank	93,205	134,761	261,881	240,975
— Geological Program	753,092	642,157	521,195	469,740
— Hydrocarbon Program	530,872	—	—	—
Inventors Assistance Grant	180,780	130,000	—	—
University Contracts	2,994,843	3,152,248	3,478,549	2,103,367
Professorships	560,622	461,515	546,121	472,084
Post Doctoral Fellowships	22,500	1,040	—	—
Scholarships and Fellowships	388,920	383,807	184,823	201,760
Hatch & Associates	122,014	246,258	—	—
Ontario Research Foundation	—	—	—	1,622
British Columbia Cancer Foundation	5,466	63,514	43,126	—
British Columbia Research Council	49,500	—	—	—
ARC — Access Program	514	4,244	—	—
University Access Program	13,861	35,918	26,771	44,159
Program Planning and Evaluation	85,675	120,486	—	—
Technical Review	798,958	72,438	—	—
Petroleum Recovery Institute	547,690	514,315	—	—
Synchrude Canada Ltd	(26,694)	581,730	—	—
	<u>\$10,589,050</u>	<u>\$10,275,691</u>	<u>\$ 8,377,812</u>	<u>\$ 6,297,220</u>

Mining and Extraction

Retorting				
— Umatac	\$ 2,948,229	\$ 2,800,255	\$ 1,532,063	\$ 1,348,402
— Lurgi	—	38,579	(114,724)	—
Tailings Treatment				
— Xana	(13,261)	332,585	692,663	617,160
— EcoPlastics	—	—	—	—
Dredging	—	(43)	174,844	—
Solvent Study	—	—	—	—
Oil Sands Demonstration Centre	36,935	218,782	(33,106)	18,253
Kruger Research	—	—	100,000	240,000
Suncor/Kruger Project	378,679	60,000	—	—
R.T.R. Project	—	—	—	100,000
Nova/Husky/Canstar	54,105	65,889	—	—
Inpro Engineering	144,327	5,338	—	—
	<u>\$ 3,549,014</u>	<u>\$ 3,521,385</u>	<u>\$ 2,351,740</u>	<u>\$ 2,323,815</u>

1981	1980	1979	1978	1977	1976	Total
\$28,000,000	\$38,000,000	\$33,161,289	\$20,290,523	\$ 9,497,220	\$ —	\$301,449,032
2,362,893	282,312	407,623	3,000	12,027	—	13,466,808
<u>\$30,362,893</u>	<u>\$38,282,312</u>	<u>\$33,568,912</u>	<u>\$20,293,523</u>	<u>\$ 9,509,247</u>	<u>\$ —</u>	<u>\$314,915,840</u>
\$ 313,017	\$ 200,000	\$ 200,000	\$ 200,000	\$ 200,000	\$ 200,000	\$ 3,192,541
2,508,783	1,336,003	1,294,191	923,636	1,400,000	1,400,000	20,260,440
218,361	65,763	22,064	59,000	—	—	1,096,010
353,953	67,842	—	—	—	—	2,807,979
—	—	—	—	—	—	530,872
—	—	—	—	—	—	310,780
1,975,243	1,291,193	880,585	634,341	731,923	—	17,242,292
353,813	167,730	160,000	147,500	55,000	—	2,924,385
—	—	—	—	—	—	23,540
85,131	121,541	107,530	136,516	49,920	—	1,659,948
—	—	—	—	—	—	368,272
4,477	—	—	—	—	—	6,099
—	—	—	—	—	—	112,106
—	—	—	—	—	—	49,500
—	—	—	—	—	—	4,758
26,882	—	—	—	—	—	147,591
—	—	—	—	—	—	206,161
—	—	—	—	—	—	871,396
—	—	—	—	—	—	1,062,005
—	—	—	—	—	—	555,036
<u>\$ 5,839,660</u>	<u>\$ 3,250,072</u>	<u>\$ 2,664,370</u>	<u>\$ 2,100,993</u>	<u>\$ 2,436,843</u>	<u>\$ 1,600,000</u>	<u>\$ 53,431,711</u>
\$ 812,790	\$ 653,734	\$ 528,210	\$ 1,103,479	\$ —	\$ —	\$ 11,727,162
239,075	319,870	—	—	55,979	6,241	545,020
333,242	223,455	170,594	15,047	—	—	2,371,485
16,829	16,598	26,490	—	—	—	59,917
—	16,760	10,898	—	—	—	202,459
—	26,343	—	—	—	—	26,343
23,069	—	—	—	—	—	263,933
—	—	—	—	—	—	340,000
—	—	—	—	—	—	438,679
—	—	—	—	—	—	100,000
—	—	—	—	—	—	119,994
—	—	—	—	—	—	149,665
<u>\$ 1,425,005</u>	<u>\$ 1,256,760</u>	<u>\$ 736,192</u>	<u>\$ 1,118,526</u>	<u>\$ 55,979</u>	<u>\$ 6,241</u>	<u>\$ 16,344,657</u>

**Statement of Revenue
Expenditure & Fund Balance
(continued)**

Oil Sands Technology and Research Fund
Ten-Year Summary For the years ended March 31

	1985	1984	1983	1982
In-Situ Oil Sands				
Peace River				
— Shell	\$ 806,095	\$ 3,037,950	\$ 3,416,430	\$ 7,413,067
Athabasca				
— Amoco	(726,689)	(66,986)	234,416	1,865,234
— Amoco/Petro-Canada	5,854,969	—	—	—
— Numac/Gulf	—	(285)	286	(36)
— Hudson's Bay	—	—	—	—
— Canterra Energy Ltd	15,199,377	46,384	6,190,000	—
— Petro-Canada/Esso	—	3,500,000	—	—
— Texaco Canada	1,340,947	41,570	—	—
Wabasca				
— General American	—	37,211	1,284,680	—
Cold Lake				
— B.P.	3,474,113	878,117	2,429,899	3,231,266
— B.P./Petro-Canada	192,092	—	—	—
— Colt Engineering	—	40,330	—	—
— Suncor - Ft. Kent	75,739	14,641	—	—
Technica	5,645	—	—	—
Gemini	—	—	37,339	123,544
Walden	—	—	—	9,346
Francis Hankin	26,500	379,905	25,695	—
Monenco	—	—	3,000	35,000
Mineralogical Study	—	1,001	—	—
Waterloo Centre	—	189,046	118,314	111,333
Chevron	506	—	—	—
Electrical Heating Study	39,007	96,323	31,149	6,294
Water Treatment Study	153,273	133,767	(4,283)	3,137
Consultants	—	—	—	—
	<u>\$26,441,574</u>	<u>\$ 8,328,974</u>	<u>\$13,766,925</u>	<u>\$12,798,185</u>
Underground Access				
Athabasca				
— Tunnelling	\$ —	\$ —	\$ —	\$ —
— Gulf Surmont Project	—	21,192	(20,803)	1,461,788
— U.T.F. Project	19,452,415	3,376,745	1,289,690	—
	<u>\$19,452,415</u>	<u>\$ 3,397,937</u>	<u>\$ 1,268,887</u>	<u>\$ 1,461,788</u>
Carbonate Trend				
Buffalo Creek				
— Union Oil	\$ 4,380,864	\$ 2,950,100	\$ 6,385,525	\$ 4,812,576
Heavy Oil				
Petro-Canada	\$ 1,541,199	\$ 993,554	\$ 2,105,364	\$ 1,577,690
A.E.C	349,412	224,545	311,857	1,617,001
Pengalta	56,470	25,934	36,808	102,475
	<u>\$ 1,947,081</u>	<u>\$ 1,244,033</u>	<u>\$ 2,454,029</u>	<u>\$ 3,297,166</u>

1981	1980	1979	1978	1977	1976	Total
\$ 6,510,798	\$22,074,583	\$18,204,757	\$ 2,547,441	\$ —	\$ —	\$ 64,011,121
4,241,687	3,086,470	3,298,545	6,983,208	5,096,570	—	24,012,455
—	—	—	—	—	—	5,854,969
(20,846)	129,684	140,662	1,200,000	—	—	1,449,465
3,199	33,372	272	—	—	—	36,843
—	—	—	—	—	—	21,435,761
—	—	—	—	—	—	3,500,000
—	—	—	—	—	—	1,382,517
—	—	—	—	—	—	1,321,891
991,585	948,474	1,645,018	4,492,932	1,217,941	—	19,309,345
—	—	—	—	—	—	192,092
—	—	—	—	—	—	40,330
—	—	—	—	—	—	90,380
—	—	—	—	—	—	5,645
99,487	—	—	—	—	—	260,370
87,268	—	—	—	—	—	96,614
—	—	—	—	—	—	432,100
—	—	—	—	—	—	38,000
—	—	—	—	—	—	1,001
—	—	—	—	—	—	418,693
—	—	—	—	—	—	506
—	—	—	—	—	—	172,773
—	—	—	—	—	—	285,894
—	6,630	23,970	—	—	—	30,600
<u>\$11,913,178</u>	<u>\$26,279,213</u>	<u>\$23,313,224</u>	<u>\$15,223,581</u>	<u>\$ 6,314,511</u>	<u>\$ —</u>	<u>\$144,379,365</u>
\$ —	\$ 17,970	\$ 39,823	\$ 32,732	\$ 86,865	\$ —	\$ 177,390
3,101,732	366,965	—	—	—	—	4,930,874
—	—	—	—	—	—	24,118,850
<u>\$ 3,101,732</u>	<u>\$ 384,935</u>	<u>\$ 39,823</u>	<u>\$ 32,732</u>	<u>\$ 86,865</u>	<u>\$ —</u>	<u>\$ 29,227,114</u>
<u>\$ 2,111,852</u>	<u>\$ 1,993,570</u>	<u>\$ 3,299,595</u>	<u>\$ —</u>	<u>\$ —</u>	<u>\$ —</u>	<u>\$ 25,934,082</u>
\$ 1,135,972	\$ 4,834,786	\$ 1,256,030	\$ —	\$ —	\$ —	\$ 13,444,595
2,747,632	58,696	—	—	—	—	5,309,143
417	17,570	—	—	—	—	239,674
<u>\$ 3,884,021</u>	<u>\$ 4,911,052</u>	<u>\$ 1,256,030</u>	<u>\$ —</u>	<u>\$ —</u>	<u>\$ —</u>	<u>\$ 18,993,412</u>

**Statement of Revenue
Expenditure & Fund Balance
(continued)**

Oil Sands Technology and Research Fund
Ten - Year Summary For the years ended March 31

	1985	1984	1983	1982
Enhanced Recovery Conventional Oil				
Vikor Resources Ltd	\$(1,036,981)	\$ 4,666,445	\$ —	\$ —
P.R.I.	—	553,804	(66,805)	304,915
PanCanadian Petroleum	334,175	116,017	—	—
McCallum, Stewart & Associates	—	—	3,427	23,246
Husky Oil	(6,439)	33,445	121,938	—
Norcen	9,613	3,513	85,289	—
Cold Lake Heavy Oil	5,663,041	111,290	240,260	—
D.B. Robinson	—	17,325	—	—
Hycal Energy	—	8,625	—	—
	<u>\$ 4,963,409</u>	<u>\$ 5,510,464</u>	<u>\$ 384,109</u>	<u>\$ 328,161</u>
Bitumen Upgrading				
Flexicoking — Exxon	\$ —	\$ —	\$ —	\$ —
Hydrocracking—E.M.R.	—	—	—	—
Hydrotreating—UOP	—	—	—	—
— Catalytic Inc	—	—	2,740	53,747
Residue Utilization Project	521,675	23,730	10,645	—
Heavy Oil Upgrading Demo Centre	20,391	13,061	—	—
Bitumen/Water Transportation Study	15,751	—	—	—
Heavy Oil Upgrading Study	30	202,520	1,094,500	494,281
Fluid Bed Combustion	—	—	—	—
— EMR/Ahlstrom Test	—	—	—	3,026
— British Columbia Research Council	19,462	—	80,108	—
Petrochemicals — Mitsubishi	—	953	3,787	2,853
Eureka Process	—	—	417,437	16,318
California Synfuels	33,859	223,378	—	12,757
REM Feasibility Study	—	—	38,586	86,414
McKinsey & Associates Study	—	—	42,000	33,000
Porta Plants Inc	—	4,465	3,632	—
Gulf Oil — Donor Process	437,000	390,000	—	—
Raylo Chemicals	—	111,046	—	—
Advance Fuel Research	8,418	18,804	—	—
RTM/ARC Process	8,786	16,214	—	—
Battelle Laboratories	248	33,582	—	—
Murphy Oil	28,049	—	—	—
Acres Davy McKee	20,000	—	—	—
	<u>\$ 1,113,669</u>	<u>\$ 1,037,753</u>	<u>\$ 1,693,435</u>	<u>\$ 702,396</u>
Technology Handling				
Data Base Administration	\$ 502,730	\$ 654,653	\$ 549,409	\$ 333,810
Technical Reports	—	—	—	—
AOSTRA Journal	124,471	32,353	5,334	—
Patent Costs	68,142	110,307	45,886	52,277
	<u>\$ 695,343</u>	<u>\$ 797,313</u>	<u>\$ 600,629</u>	<u>\$ 386,087</u>
Training Activities				
	\$ 243,757	\$ 328,732	\$ 289,725	\$ 207,109
International Activities				
	\$ 444,666	\$ 325,160	\$ 232,466	\$ 244,408
Authority Costs				
	\$ 37,726	\$ —	\$ —	\$ —
	<u>\$73,858,568</u>	<u>\$37,717,542</u>	<u>\$37,805,282</u>	<u>\$32,858,911</u>
Excess of revenue over expenditures	\$(21,801,760)	\$18,770,565	\$ 4,571,195	\$ (881,350)
Fund balance at beginning of period	25,127,778	6,357,213	1,786,018	2,667,368
Fund balance at end of period	<u>\$ 3,326,018</u>	<u>\$25,127,778</u>	<u>\$ 6,357,213</u>	<u>\$ 1,786,018</u>

1981	1980	1979	1978	1977	1976	Total
\$ —	\$ —	\$ —	\$ —	\$ —	\$ —	\$ 3,629,464
20,669	14,888	—	—	—	—	827,471
—	—	—	—	—	—	450,192
—	—	—	—	—	—	26,673
—	—	—	—	—	—	148,944
—	—	—	—	—	—	98,415
—	—	—	—	—	—	6,014,591
—	—	—	—	—	—	17,325
—	—	—	—	—	—	8,625
<u>\$ 20,669</u>	<u>\$ 14,888</u>	<u>\$ —</u>	<u>\$ —</u>	<u>\$ —</u>	<u>\$ —</u>	<u>\$ 11,221,700</u>
\$ —	\$ —	\$ —	\$ —	\$ —	\$ 353,829	\$ 353,829
—	—	—	—	—	214,520	214,520
—	88,785	87,398	—	—	—	176,183
144,685	—	—	—	—	—	201,172
—	—	—	—	—	—	556,050
—	—	—	—	—	—	33,452
65,158	—	—	—	—	—	15,751
—	—	—	—	—	—	1,856,489
—	—	—	—	—	—	3,026
2,877	265,855	359,194	45,074	—	—	99,570
—	—	—	—	—	—	680,593
—	—	—	—	—	—	433,755
—	—	—	—	—	—	269,994
—	—	—	—	—	—	125,000
—	—	—	—	—	—	75,000
—	—	—	—	—	—	8,097
—	—	—	—	—	—	827,000
—	—	—	—	—	—	111,046
—	—	—	—	—	—	27,222
—	—	—	—	—	—	25,000
—	—	—	—	—	—	33,830
—	—	—	—	—	—	28,049
—	—	—	—	—	—	20,000
<u>\$ 212,720</u>	<u>\$ 354,640</u>	<u>\$ 446,592</u>	<u>\$ 45,074</u>	<u>\$ —</u>	<u>\$ 568,349</u>	<u>\$ 6,174,628</u>
\$ 116,073	\$ 198,691	\$ 121,152	\$ —	\$ —	\$ —	\$ 2,476,518
91,865	—	—	—	—	—	91,865
—	—	—	—	—	—	162,158
66,184	78,623	—	—	—	—	421,419
<u>\$ 274,122</u>	<u>\$ 277,314</u>	<u>\$ 121,152</u>	<u>\$ —</u>	<u>\$ —</u>	<u>\$ —</u>	<u>\$ 3,151,960</u>
\$ 200,439	\$ —	\$ —	\$ —	\$ —	\$ —	\$ 1,269,762
\$ 177,005	\$ —	\$ —	\$ —	\$ —	\$ —	\$ 1,423,705
\$ —	\$ —	\$ —	\$ —	\$ —	\$ —	\$ 37,726
<u>\$29,160,403</u>	<u>\$38,722,444</u>	<u>\$31,876,978</u>	<u>\$18,520,906</u>	<u>\$ 8,894,198</u>	<u>\$ 2,174,590</u>	<u>\$311,589,822</u>
\$ 1,202,490	\$ (440,132)	\$ 1,691,934	\$ 1,772,617	\$ 615,049	\$ (2,174,590)	\$ 3,326,018
1,464,878	1,905,010	213,076	(1,559,541)	(2,174,590)	—	—
<u>\$ 2,667,368</u>	<u>\$ 1,464,878</u>	<u>\$ 1,905,010</u>	<u>\$ 213,076</u>	<u>\$(1,559,541)</u>	<u>\$ (2,174,590)</u>	<u>\$ 3,326,018</u>

Information Dissemination

To make the data available and more widely accessible from our university research and laboratory funded programs at other institutions, we now publish the AOSTRA Journal of Research. Each year we sponsor one major conference and intermittently hold smaller workshops on specific topics.

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AOSTRA Journal of Research

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Proposals for financial support are welcomed by AOSTRA, and should be submitted on an application form available from either our Edmonton or Calgary office. In addition, when AOSTRA identifies a technical need which is not being satisfactorily fulfilled, it will issue a "Call for Proposals" and will invite applications for research on such topics.

All applications should be submitted to the Registrar, at the following address:

Registrar

Alberta Oil Sands Technology
and Research Authority
500 Highfield Place
10010 - 106 Street
Edmonton, Alberta T5J 3L8

Completed applications are presented at the next regularly scheduled Board meeting, and a technical review procedure established at that time. Only designated experts who have signed confidentiality agreements with AOSTRA have access to the applications.

Due to the large number of applications submitted, not all proposals can be supported. Upon notification of acceptance of a proposal, AOSTRA will work with the successful applicant in the preparation of an agreement which will specify the development schedule, the cost, and the method of carrying out the project.

The form of the agreement will depend on the nature and purpose of the project. AOSTRA has developed a set of guidelines to assist in the preparation of agreements, and these are described briefly below.

A. Technology Ownership and Use Rights in AOSTRA/Industry in Situ Agreements

1. AOSTRA obtains patents and generally owns all new technology.
2. AOSTRA is the sole licensing agent for new technology in Canada.
3. AOSTRA and the Company can both license outside Canada.
4. Regardless of who grants a license, licensing income is shared equitably.
5. Prior to distributing licensing income, licensing costs will be subtracted.
6. AOSTRA agrees to keep the new technology confidential, but must be able to grant a license to any third party at a fair market value fee. The fee will be established by agreement with the Company, and failing agreement, by arbitration.
7. AOSTRA has the right to include the Company's prior technology, as necessary, to complete its licensing package. The Company's approved expenditures for developing prior technology are recognized in distributing the licensing income.
8. AOSTRA, Alberta Government agencies (including crown corporations), and the industrial parties to the agreement and their affiliates, have the right to use both prior and new technology (including patents) without payment of any licensing fees. All others pay a license fee.
9. AOSTRA can place a Technical Representative in the Company's office, at Project expense.
10. The Technical Representatives' duties and responsibilities will include acquiring and assembling technology and monitoring the progress of the Project.
11. AOSTRA and the other parties to the agreement jointly own all physical assets and share all revenues, including salvage value of assets and proceeds from sale of products.

12. AOSTRA reserves the right to limit participants to original signatories.
13. AOSTRA may bring Consultive Participants into a Project, at terms to be negotiated in a similar manner to that used in setting license fees. Such Consultive Participants may be granted full use rights to the technology but no decision-making rights, or rights to tangible and intangible assets.

B. Assisting in the Development of Unproven Inventions Covered by Patents or Patent Applications

1. AOSTRA will recognize the proprietary position of inventors by according them a share of future licensing revenues.
2. The sharing formula will be based on the level of expenditure by each party, in which a deemed prior expenditure level is negotiated to reflect the value of the invention.
3. Prior to distributing licensing income, adjustments will be made for payments to third parties who assist in the further development or commercialization of the invention.
4. The agreement with the inventor will ensure that AOSTRA will have the right to use and license the prior invention as part of a total technology package.

Depending upon circumstances, this may be provided by:

- i) immediate assignment of ownership to AOSTRA;
- ii) assignment of ownership after the expenditure by AOSTRA of an agreed-upon sum of money;
- iii) an irrevocable license to AOSTRA to use, make, or sell the invention, without legal transfer of title, if this would be in the general interest of Alberta.

C. Testing Commercially Available Processes or Equipment for Oil Sands Applications

In the case where there is economic uncertainty involved in the use of existing processes or equipment which have not previously been tested for oil sands application, AOSTRA may decide to fund a demonstration test. The proprietary rights will normally be owned by other parties. In lieu of obtaining a share in such proprietary rights, AOSTRA would attempt to recover three times its share of the cost of the demonstration by one of the following mechanisms:

1. sale of data by AOSTRA to industry;
2. share of licensing revenue;
3. share of revenue from manufacturing equipment;
4. share of product revenue from commercial application.

The multiple of three was selected to reflect both the risk involved and the time value of money.

D. Handling of University Projects

1. Applications will be accepted from all Canadian universities and will be reviewed by a panel comprised of experienced researchers.
2. The panel will present its recommendations to the Authority Members no less frequently than semi-annually.
3. Approved projects will be carried out under the direction of the principal university researcher, with technical support from the Authority as is deemed appropriate.
4. AOSTRA will promote the involvement of industry as "Consultive Participants". Each such participant will pay a specified percentage of the cost of the Project and will obtain full use rights to the technology developed.
5. AOSTRA will own patents developed in the projects. An honorarium will be paid to the inventor on filing, and when the patent application is granted.

6. AOSTRA will, not less than annually, review the following subjects:

- a) priorities for University research;
 - b) progress and results of University projects;
 - c) progress and results of University projects;
- and will seek and employ such expert advice as required to effectively conduct such reviews.

E. International Cooperative Agreements

1. AOSTRA is willing to carry out a select set of analyses on samples submitted to it by another country at no cost. These analyses will assist AOSTRA and that country in preparing a resource development plan.
2. AOSTRA will enter into international agreements for data exchange, personnel exchange, and for joint projects. Examples are as follows:
 - a) A jointly financed project in which exclusive use and licensing rights to inventions would be granted to each party in its own country, and with shared or symmetrical licensing rights in other countries.
 - b) The costs for exchange of scientists would normally be
 - i) sending country pays salary and traveling costs to the host country
 - ii) host country pays living and all employment expenses.
3. AOSTRA will seek opportunities to market its own technology in other countries, as required in our joint project agreements. AOSTRA will attempt to use Albertan and Canadian companies in the implementation of such technology; for example, in detailed design, procurement, and construction activities.

F. Albertan/Canadian Requirements in AOSTRA-Supported Projects

The policy of the Authority is to have all contracts for services, material, and equipment awarded on a competitive basis, giving recognition to quality, price, and date of delivery. To the fullest extent to which the same are procurable or possible, Albertan, or failing which, Canadian labor, parts, materials, equipment, sub-contractors, suppliers, and services shall be used in all AOSTRA-sponsored research projects.

G. Computer Modeling

Experience has shown that there is an optimum sequence of steps in the development of new oil recovery technology, starting with laboratory tests on new concepts, and terminating with large scale field demonstration projects. Mathematical models of reservoir recovery processes can assist in this sequence by reducing the time involved and in guiding the development program. AOSTRA is committed to making full use of such models for its own operations and to encouraging their use on joint projects with industry. The following approaches will be followed:

1. Emphasis will be placed on the simulation of specific processes and site-specific geology in ongoing and proposed field projects.
2. Primary goals will include:
 - i) optimum organization and handling of project data;
 - ii) planning of future experimental and developmental programs;
 - iii) interpretation of project results and comparison of processes;
 - iv) assistance in the marketing of technology.

AOSTRA will make available data from AOSTRA-sponsored projects to assist in validating models being developed by private or public modeling organizations. This disclosure will be done in a manner consistent with AOSTRA's confidentiality agreements, and with specific use rights to the models accruing to AOSTRA.